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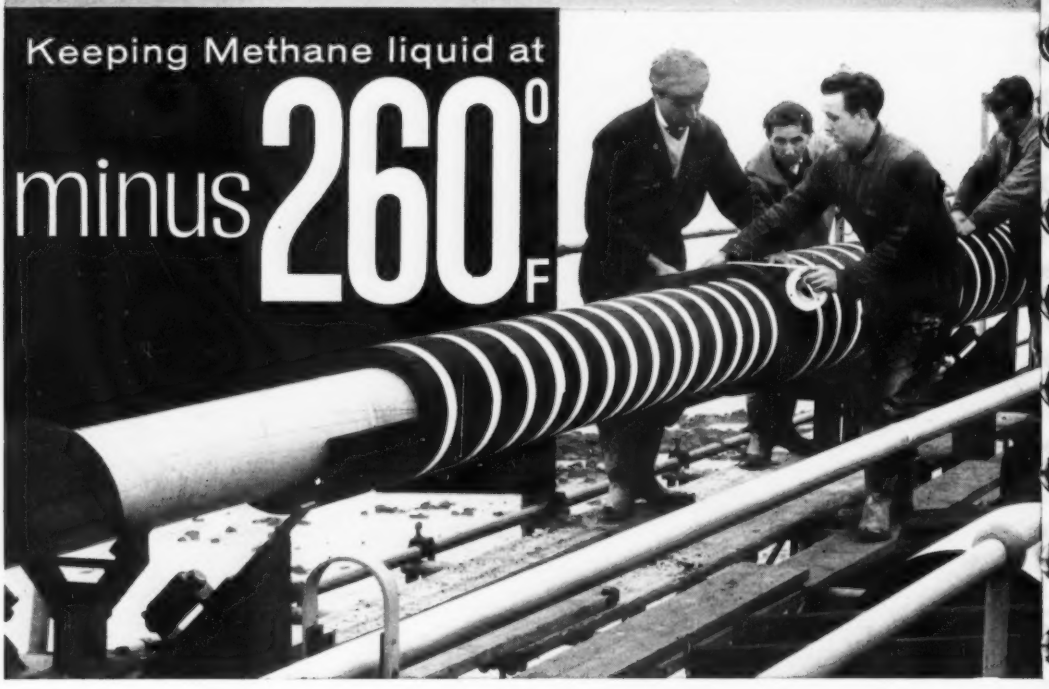

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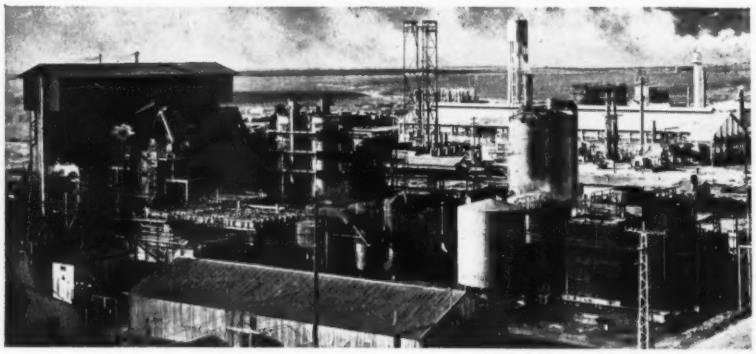

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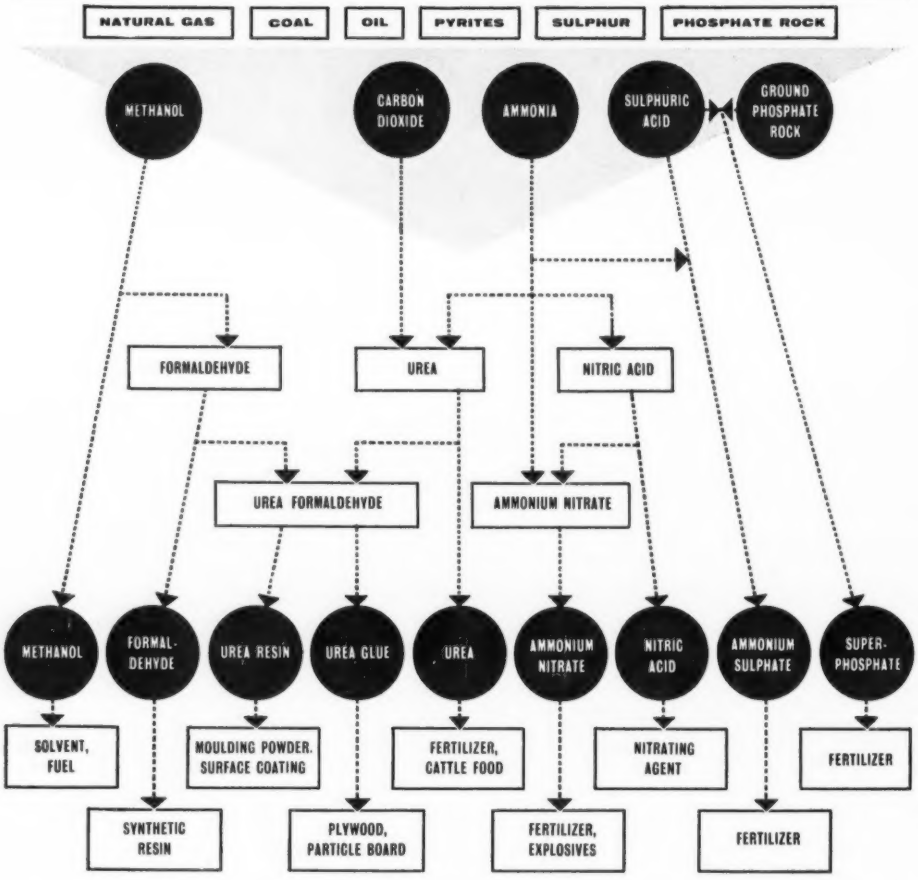

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INTERNATIONAL TRADE IN FERTILIZER NITROGEN

NOW AT AN annual level of 2 million tons N, international trade in fertilizer nitrogen has doubled in volume during the last 30 years but has nevertheless expanded at an appreciably slower rate than production and consumption. Whereas in 1928 the ratio between world consumption of fertilizer nitrogen and exports was 2 to 1, to-day this ratio is 4 to 1. This divergent trend cannot be attributed either to the economic depression of the 1930's nor to the disruption of the Second World War, although both had profound effects on the growth and pattern of this trade; the rapidly expanding basis of world production is exerting a more powerful influence. A parallel trend reflecting the technological advances of the Industry is manifested by the changes in the types of nitrogen fertilizers entering world trade and it is seen that whereas the volume of exports has doubled in terms of nitrogen, the gross tonnage of fertilizer materials has only risen by one-third in 30 years. In this period Chilean nitrate, which formerly accounted for the bulk of exported material, has given way to an increasing variety of fertilizers based on the use of synthetic and by-product ammonia while at the same time the need for the growing production to find outlets has led to the development of new markets and to a changing pattern of world trade.

Principal Exporters of Fertilizer Nitrogen
(000 tons N)

	1928	*1938*	*1948*	*1958*
West Germany ...	281	104	1	337
Japan	—	—	5	238
United States ...	26	10	171	215
Belgium	10	34	71	228
Chile	440	240	275	195
Italy	5	1	9	171
Norway	30	65	63	170
Canada	20	39	55	170
Netherlands ...	8	45	1	160
United Kingdom	90	68	80	61
Others	—	4	9	55
Total ...	**910**	**610**	**740**	**2,000**

In 1928 only three countries, the United Kingdom, Germany and Chile, supplied over 90% of all nitrogen fertilizer exports. Since then, with substantial increases in their synthetic nitrogen capacities and exports, Belgium, Italy, the Netherlands, Norway, Canada, the United States and Japan have joined in the dominance of the international market and to-day these 10 countries together supply over 90% of the total volume of exports.

The number and size of the markets for fertilizer nitrogen have increased with the growth of production and exports since 1928. In that year Europe received nearly one-half of total world exports whereas to-day, when the actual tonnage is 10% greater, the share of the total has declined to 27%. Asia, which 30 years ago received only 15% of all exports, has become the principal market and is now the destination of nearly 40% of all nitrogen fertilizer exports with imports totalling 757,000 tons N.

A number of new forces, both political and economic, are now emerging to exert an increasing influence on the pattern of supply and demand. With the expansion of indigenous supplies in many major markets there is evidence of changes in the quantities as well as in the qualities of nitrogen fertilizer exports, possibly leading to a new concept of international trade.

NITROGEN FERTILIZERS

Sodium Nitrate

Chilean nitrate, which during the 19th Century accounted for virtually all nitrogen fertilizer exports, met growing competition from by-product ammonium sulphate and to a lesser extent from calcium cyanamide and calcium nitrate in the years immediately preceding the First World War, but it was not until the 1920's that it was seriously challenged by the more versatile production of the new synthetic capacity, of which the rapid growth had been greatly stimulated by the war itself. Synthetic sodium nitrate did not account for more than 3% of total world production in the 1920's

and its share of exports was commensurately low.

In 1928 half the total volume of fertilizer nitrogen exports, some 900,000 tons, was still in the form of sodium nitrate, 95% of it originating from Chile. Growing competition from ammonium sulphate, calcium nitrate, calcium cyanamide and ammonium nitrate reduced this share to 40% by 1938. Since the Second World War, the volume of sodium nitrate exports has not increased as have the other principal types of nitrogen fertilizers, and it now accounts for only 10% of the world total.

Ammonium Sulphate

During and after the First World War a substantial measure of synthetic ammonium sulphate capacity was installed, particularly at the enormous plants at Merseburg (Leuna) and Oppau in Germany and at Billingham in the United Kingdom. With this addition to established by-product output of a large quantity of synthetic production, ammonium sulphate entered world markets in the 1920's in growing volume and at an increasingly competitive price. By 1928 it accounted for 36% of all fertilizer nitrogen exports. During the 1930's, in the face of growing competition from ammonium nitrate and lime ammonium nitrate and although by-product output was seriously curtailed by the economic depression, ammonium sulphate maintained its share of the export market and in 1938 still accounted for 36% of the volume of international trade in fertilizer nitrogen.

AMMONIUM SULPHATE EXPORTS

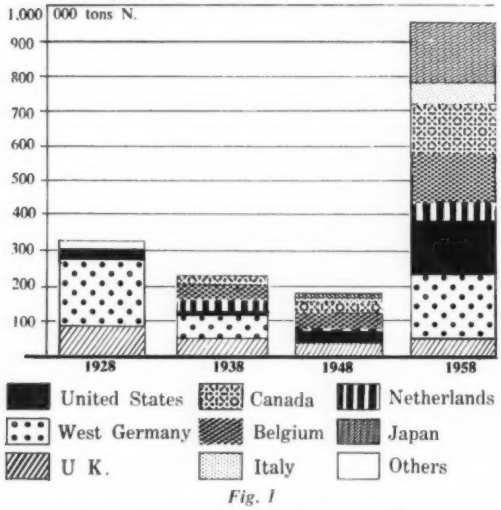


Fig. 1

Since World War II ammonium sulphate has if anything slightly increased its share of the total exports, largely on account of its suitability for the Asian market. Exports in 1958 exceeded 800,000 tons of nitrogen content a year but their level is static whereas that of ammonium nitrate and of urea is rising rapidly.

Calcium Cyanamide

Playing a less important part than ammonium sulphate and sodium nitrate, calcium cyanamide has never accounted for more than 6% of world nitrogen fertilizer exports, a share it obtained during the early 1930's. The only countries to have shipped it in substantial quantities have been Germany, Norway, Canada and Japan, and to-day it accounts for less than 3% of international trade.

Calcium Nitrate

Although it has always been exported in large quantities by Norway and Germany, calcium nitrate has never ranked higher than third among nitrogen fertilizers in world trade. The volume of shipments, which in 1914 accounted for only 2% of the world total, rose in the inter-war years at a much slower rate than that of ammonium sulphate and by 1938 did not exceed 100,000 tons N or 15% of the world total. Since then its share of international trade has fallen to about 8% largely as production of higher analysis materials has increased at an appreciably faster rate.

Ammonium Nitrate

A feature of the post-war growth of fertilizer nitrogen trade has been the increasing part played by ammonium nitrate and lime ammonium nitrate. In 1938 these materials together accounted for less than 3% of the world total, a share that has since increased to nearly 25%. This marked trend has been caused largely by the sharp rise in ammonium nitrate capacity in all the major producing countries, with the exception of Japan, and to the popularity of lime ammonium nitrate with European farmers, which has accompanied substantial production.

The high plant food content of ammonium nitrate, effecting economies when transport over long distances is involved, has favourably influenced its share of international trade. In this respect it is significant that ammonium nitrate's share of international trade has risen

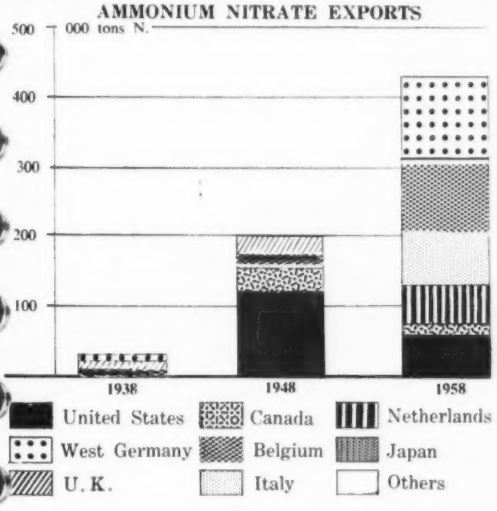


Fig. 2

at a time when Asia, where ammonium sulphate enjoys great popularity, has emerged as the principal market for nitrogen fertilizers.

Urea

The most recent major nitrogen fertilizer to make its impact on international trade, urea does not yet account for more than 10% of total exports but is increasing its share at a faster rate than any other fertilizer material. Its suitability for agronomic conditions in Asia, high nitrogen content and increasingly competitive price, promote outlets for a rapidly expanding production capacity and promise to improve urea's position still further. The principal exporters of fertilizer grade urea are Japan, Netherlands, Italy, the United States and Canada, but many of the new plants throughout the world are likely to produce an export surplus which will seek outlets.

Other Materials

As ammonium sulphate, ammonium nitrate, urea, sodium nitrate, calcium nitrate and calcium cyanamide together account for 95% of fertilizer nitrogen exports, none of the materials comprising the balance as yet play any significant part in international trade. In the case of anhydrous and aqua ammonia, supplies entering world markets, which at present originate principally from the United States, are as yet limited in volume by technical difficulties of bulk of transportation of these materials over great distances. The part played in international trade by ammonium phosphates, nitrophosphates and ammonium chloride is restricted by the relatively limited capacity for their production, but appears to be growing steadily. Similarly, the volume of nitrogen exported in compound fertilizers is on the increase, particularly from Western Germany, Belgium, Netherlands and Japan.

COUNTRIES OF ORIGIN *

Chile

1928 440,000 tons N (100% SN)†
1938 240,000 tons N (100% SN)
1948 274,700 tons N (100% SN)
1958 195,400 tons N (100% SN)

The first country to export nitrogen materials on a commercial scale, when small shipments were made to the United Kingdom and the United States in 1831, Chile dominated world trade until World War I. Soon after its start, a struggle between the Central Powers and the Allies for control of supplies of natural nitrate—essential at that time for the manufacture of explosives as well as for fertilizer—was quickly terminated in favour of the Allies with the Battle of the Falkland Islands in December, 1914. With the Chilean nitrate industry virtually under Allied control, the producers were concerned principally in operating their properties at their fullest capacity to meet war demands, and gave little heed to the development of improved techniques to meet competition stimulated largely by the high price of their own product. The Guggenheim process was introduced too late to sustain effectively the Chilean nitrate industry, in its virtual dependence on export markets, against increasingly strong competition from synthetic products. Although exports reached a record total of 3,263,800 short tons in 1929 they fell sharply under the impact of the economic depression in the early 1930's and, whilst fluctuating with the fortunes of the industry, have never regained their position.

* In this section statistical details show Total Nitrogenous Fertilizer Exports for each country and the percentage of principal types of fertilizer exported.
†SN = Sodium nitrate

The isolated geographical position of Chile has been an obstacle to the maintenance of the volume of her exports of nitrate, particularly as she has always looked to Europe for an outlet for between one-third and one-half of her sales. Although relatively cheap at the point of production, Chilean nitrate is at a distinct disadvantage to higher analysis materials when long distance transport is involved, and at times freight charges have accounted for as much as 65% of its selling price.

Directing over three-quarters of her exports to her traditional markets in Europe and North America, Chile has failed to establish a position in the expanding Asian market comparable with that obtained by the majority of her competitors. Although her share of world

Destination	*1928*	*1938*	*1948*	*1958*
	%	*of Total*	*Exports*	
W. Europe	32	53	32	42
Asia	3	2	2	5
Africa	6	2	21	4
N. America	58	38	43	37
C. & S. America ...	1	4	3	12

markets will progressively decline, Chile should be in a position to maintain her exports at their present level of 200,000 tons N for several years, provided that the measures to improve the financial stability of the industry succeed. Trade is conducted by COVENSA, the Government controlled Nitrate Sales Corporation.

United Kingdom

1928 90,800 tons N (100% AS)†
1938 67,800 tons N (92% AS. 8% AN)
1948 80,300 tons N (55% AS. 40% AN. 5% Others)
1958 61,200 tons N (100% AS)

Although concentrating primarily on the requirements of its domestic market, the British nitrogen industry has, in most years, accounted for some 10% of total world exports, and in the inter-war years was surpassed as an exporter only by Chile and Germany. Since then, however, with the spectacular growth of the domestic market, the emphasis on foreign trade of United Kingdom nitrogen fertilizers has declined and in 1958 her share of world trade had fallen to 3%.

United Kingdom nitrogen exports have always been predominantly in the form of ammonium sulphate. Whereas 30 years ago British territories received only one-third of her nitrogen exports, in recent years, partly as a result of tariff preferences, the proportion has increased, and in 1958 Commonwealth countries received more than 80% of United Kingdom exports. This close relationship between the volume of exports and domestic

Destination	*1928*	*1938*	*1948*	*1958*
	%	*of Total*	*Exports*	
W. Europe	34	22	47	14
Asia	64	54	30	62
Africa	1	9	13	11
N. America	—	4	—	1
C. & S. America ...	1	11	8	12

demand and the dependence on Dominions, Colonial and former Colonial Territories for a market for surplus production is a feature which is not paralleled in any other major exporting country. It is a pattern which may, however, be changed radically within the next decade by the expansion of domestic capacity in India, Pakistan, South Africa and the West Indies, and by the weakening of economic ties as a result of international trade agreements. United Kingdom exports are effected by Imperial Chemical Industries Ltd. on behalf of the British Sulphate of Ammonia Federation Ltd.

West Germany

1928 280,500 tons N (68% AS. 29% CN. 3% Others)
1938 104,400 tons N (57% AS. 27% CN. 7% AN. 9% Others)
1948‡
1958 336,900 tons N (56% AS. 1% CN. 41% LAM. 2% Others)

The expansion of the German nitrogen industry and the growth of its exports have given it a larger share of the international trade in fertilizer nitrogen than any other country. In the last 30 years production of fertilizer nitrogen has risen by one-third, while exports have increased by over one-fifth in spite of the heavy material damage suffered in the Second World War. In 1928 production amounted to 800,000 tons N with exports exceeding 280,000 tons N, but in 1938 while the level of production had been maintained, exports had fallen sharply to 104,000 tons N, a result not only of rising domestic consumption but of the after effects of the economic depression of the 1930's and the installation of a substantial measure of capacity in many European countries which were formerly important markets for German exports. In 1948 production in West Germany was only one-quarter of a million tons N and exports were negligible, and yet within the last

†AS = Ammonium sulphate AN = Ammonium nitrate CN = Calcium nitrate
LAM = Lime ammonium nitrate CC = Calcium cyanamide U = Urea
‡ less than 1,000 tons N.

10 years the rate of recovery has been such that production now exceeds one million tons N with exports in 1958 totalling 336,952 tons N or 17% of the world total. This recovery is the more remarkable for the fact that over one-half of Germany's pre-war nitrogen capacity was located in what is now East Germany.

Ammonium sulphate has always accounted for a high proportion of German nitrogen exports and although the volume of exports in this material has not increased as fast as that of lime ammonium nitrate it still accounts for over one-half of the total. Calcium nitrate, on the other hand, which in 1928 accounted for nearly one-third of the volume of exports, has declined sharply in importance and now accounts for less than 1%. Its place has been taken largely by lime ammonium nitrate and ammonium sulphate nitrate which together accounted for 140,000 tons N in 1958. Fertilizer grade urea, whilst representing only as yet a small proportion of total exports, holds promise of improving its position in the future.

Before World War II over one-half of Germany's fertilizer nitrogen exports was sold in Europe, but the bulk of supplies from Western Germany is now directed to Asia, with Europe taking only one-third. Supplies to Africa and Central and South America have increased, whereas North America no longer represents as important a market for German

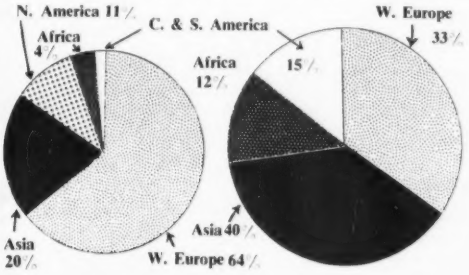


Fig. 3. W. Germany. Exports of fertilizer by principal destinations.

nitrogen as it did in the 1920's when it accounted for over 10% of the total. At present supplies to European markets are evenly distributed between ammonium sulphate and lime ammonium nitrate, but of those directed to Asia, the balance favours lime ammonium nitrate. Export sales originate almost exclusively from the three main producers, Badische Anilin and Soda Fabrik A.G., Farbwerke Hoechst A.G. and the group of producers in the Ruhr whose output and sales are co-ordinated by Ruhrstickstoff A.G.

Belgium

1928 9,700 tons N (53% AS. 47% Others)
1938 34,200 tons N (85% AS. 13% AN. 2% Others)
1948 70,800 tons N (74% AS. 12% AN. 14% Others)
1958 227,700 tons N (56% AS. 39% AN. 5% Others)

Although she remained a net importer of fertilizer nitrogen until World War II, Belgium has ranked among the world's major exporters since 1929, when the volume of her exports rose to 20,000 tons N, double that of the preceding year. With the installation of additional capacity, exports again doubled from 1930 to 1931, when they reached 50,694

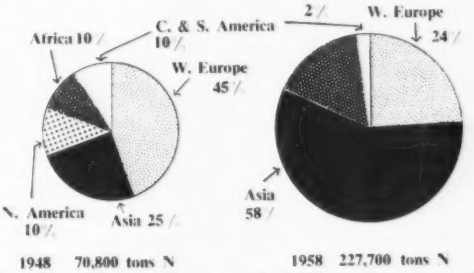


Fig. 4. Belgium. Exports of fertilizer by principal destinations.

tons N, and although the excess of world supply over demand forced their reduction in following years, Belgium retained her position in international trade. Recovery from World War II was rapid and by 1948 Belgian exports totalled over 70,000 tons N or nearly 10% of the world total. Within the last 10 years they have trebled and have still further improved Belgium's position in relation to other exporting countries. To-day, in spite of the intensity of her domestic fertilizer application, the third highest in Europe, Belgium exports as much as 75% of her total fertilizer nitrogen production, a proportion comparable only with those achieved by Chile and Norway.

Ammonium sulphate has always played a dominant rôle in Belgian supplies, although in recent years ammonium sulphate nitrate, ammonium nitrate and ammonium phosphates have progressively improved their positions and, with the installation of new capacity, urea is claiming increasing attention.

With her nitrogen industry geared to the demands of foreign markets, Belgium has directed an increasing proportion of supplies to Asia, now the destination of over one-half of her exports. In 1958 China alone received nearly 100,000 tons of Belgian fertilizer nitrogen. All exports sales are effected by the Comptoir Belge de l'Azote (COBELAZ) of Brussels.

Netherlands

1928 7,900 tons N (100% AS)
1938 44,700 tons N (98% AS. 2% Others)
1948 1,400 tons N (100% AS)
1958 159,900 tons N (41% AS. 37% AN. 18% U. 4% Others)

The growth of the nitrogen industry in the Netherlands has been similar to that of Belgium, and although the level of domestic consumption per acre of arable land is higher, the industry has been developed not so much to meet domestic demand or to provide a source of nitrogen in case of national emergency, as to exploit conditions created by low operating costs and ample supplies of coal which favour the establishment of a large export trade.

Although she has continued to import large quantities of fertilizer nitrogen, the Netherlands has been a major exporter since the early 1930's. By 1938 she was responsible for some 8% of world exports and although her post-war recovery in this respect was slower than that of Belgium, her exports have since doubled and she has maintained her share of world markets.

In 1958 the Netherlands exported 160,000 tons of fertilizer nitrogen of which ammonium sulphate accounted for 66,000 tons, lime ammonium nitrate 60,000 tons and urea 26,000 tons. Virtually all the ammonium sulphate manufactured in the Netherlands is sold abroad, but the volume of exports of this material has not risen appreciably since 1952 whereas within the same period that of lime ammonium nitrate has almost doubled.

Thirty years ago Europe received two-thirds of Dutch nitrogen fertilizer exports whereas to-day 4/5 of the total is equally divided between Europe, Asia and North America. The bulk of supplies to Europe and Asia is in the form of ammonium sulphate while shipments to North America are predominantly in the form of lime ammonium nitrate. Exports to Africa, nearly one-half in the form of urea, account for almost 10% of the Netherlands total and a slightly smaller quantity shipped to Central and South America is composed mainly of ammonium sulphate

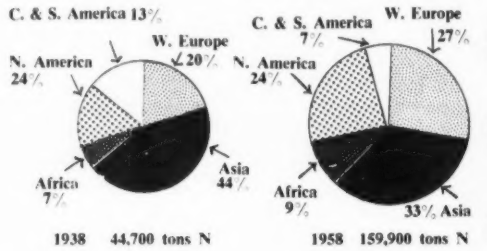


Fig. 5. Netherlands. Exports of fertilizer by principal destinations.

and urea. Export sales are effected by the Centraal Stikstof Verkoopantoor (C.S.V.) in the Hague.

Norway

1928 30,500 tons N (34% CC. 53% CN. 13% Others)
1938 65,300 tons N (12% CC. 85% CN. 3% Others)
1948 63,200 tons N (10% CC. 89% CN. 1% Others)
1958 170,400 tons N (1% CC. 90% CN. 8% U. 1% Others)

Exporting 80% of her output, a higher proportion than Belgium and, with the exception of Chile, the highest in the world, Norway was the first country to establish a synthetic nitrogen industry on a commercial scale. Taking advantage of ample supplies of cheap hydro-electric power, she obtained an important share of world markets in 1930 and although her nitrogen capacity has not increased as rapidly, Norway's status as an exporter remains similar to that of Belgium and the Netherlands.

Unlike other West European countries, Norway continues to find Europe her principal market which to-day accounts for 85% of her total exports of nitrogen fertilizers. This concentration on the European market is, of

Destination	*1928*	*1938*	*1948*	*1958*
	% of Total Exports			
W. Europe	92	72	75	85
Asia	2	—	10	2
Africa	1	12	10	3
N. America	5	16	—	7
C. & S. Amercia ...	—	—	5	3

course, a result of the dominance of calcium nitrate in the Norwegian supply pattern. In 1958 Denmark and Sweden together received 80% of all her exports.

Since 1953 urea has supplanted calcium cyanamide as the second most important fertilizer export and with the growing emphasis

on its production has increased its share of Norwegian supplies from 4% to over 8% in the last five years. As this trend continues, Norway can be expected to show greater interest in Asian, African and South American markets.

Italy

1928 4,800 tons N (100% AS)
1938‡
1948 8,600 tons N (61% AS. 28% AN. 11% Others)
1958 170,900 tons N (37% AS. 49% AN. 14% U)

With supplies fluctuating sharply in quantity during the 1930's, it is only since the Second World War that Italy has become firmly established as a major exporter of fertilizer nitrogen. Her position has, in fact, advanced appreciably within the last five years when her exports have risen from 50,000 to over 170,000 tons N. Whereas before the war virtually all Italian shipments were in the form of ammonium sulphate, this now accounts for less than one-half following the substantial growth of production of both ammonium nitrates and urea. Since the displacement of Soc. Montecatini as the principal supplier in the domestic market by the advent of ENI in 1958, the potential export tonnage to be marketed by SEIFA, which effects all sales on behalf of Montecatini and associates and by-product sulphate manufactures, has risen substantially. With the growth of Italy's capacity to 650,000 tons N there appears to be a surplus of 350,000 tons N.

Italy. Ammonium nitrate store at the Ferrara plant of Società Montecatini.

Italy to-day looks to Asia for a market for 50% of its exports, and shipments to this area are composed one-half of ammonium sulphate, one-quarter of ammonium nitrate and one-quarter of urea. Europe ranks next in importance, Yugoslavia and Greece taking the bulk of supplies; the plant installation in progress in

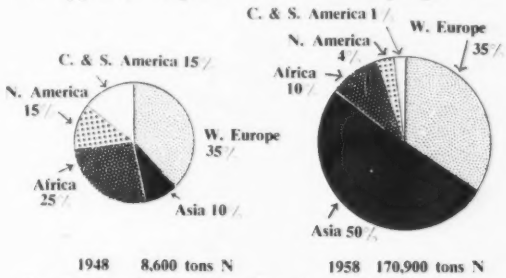


Fig. 6. Italy. Exports of fertilizer by principal destinations.

these countries may restrict this valuable outlet for Italy's export surplus. Africa takes some 10% of Italian exports, but here again the installation of a substantial production capacity in Egypt threatens to affect the pattern of supplies.

Canada

1928 20,000 tons N (92% CC. 8% AS)
1938 38,500 tons N (65% CC. 35% AS)
1948 55,200 tons N (55% AS. 43% AN. 2% Others)
1958 170,300 tons N (88% AS. 12% AN)

Nitrogen fertilizer exports from Canada have risen steadily after the First World War until the early 1930's when they were cut sharply by the economic depression. By 1938 they had, however, regained their former level of 40,000 tons N and have almost doubled since then. In spite of the growth of her nitrogen capacity during the war the post-war growth of Canada's exports, now at an annual level of 170,000 tons N, has been less spectacular than that of West Germany, Italy, the

Destination	*1928*	*1938*	*1948*	*1958*
	% of Total Exports			
W. Europe	—	—	6	—
Asia	—	6	21	32
Africa	—	1	6	—
N. America	100	92	55	64
C. & S. America ...	—	1	12	13

Netherlands or Japan. The Canadian nitrogen industry was established in the first place to make use of cheap and abundant electric power, and is now in the particularly advantageous position of also having the choice of cheap natural gas, coal and fuel oil, all in

‡ Less than 1,000 tons N.

abundant supply. From the start, the Industry has been directed towards export markets and in particular that of the United States. In the last 10 years, although this market has become increasingly competitive with the growing United States production, Canadian nitrogen fertilizer exports have nevertheless expanded fourfold. At the same time, whereas prior to World War II, 90% of her supplies were directed to the U.S.A., this proportion has fallen to one-half. Central America and Asia are now taking a progressively larger share of Canadian supplies.

With the substantial growth of Canada's synthetic ammonia capacity during World War II, calcium cyanamide was displaced from its dominant position by expanding ammonium sulphate manufacture which in turn has since been supplanted by ammonium nitrate while ammonium phosphates and compound fertilizers are now playing increasingly important parts. The addition of two large urea plants to Canadian capacity should within the next two years promote the trend towards South American and Asian markets.

United States

1928 25,900 tons N (83% AS. 17% Others)
1938 10,400 tons N (73% AS. 27% Others)
1948 170,800 tons N (22% AS. 76% AN. 2% Others)
1958 215,400 tons N (67% AS. 26% AN. 7% Urea)

Although she has only become a net exporter of fertilizer nitrogen since 1956, the United States ranks among the world's five principal exporting nations, owing her position largely to the war with its powerful stimulus to the growth of her synthetic ammonia capacity, which has also prompted a very substantial increase in her domestic consumption. Another factor which has affected the growth of an export surplus is the continued flow of a substantial volume of imports consistently exceeding an annual level of 200,000 tons N since the war and which reached 400,000 tons N in 1953 and 1954. The sharpest rise in the volume of exports was a result of a large surplus created by the stagnation of home sales in the fertilizer year 1955/56. This situation threatens to repeat itself with the continued growth of United States capacity, although large shipments made under Foreign Aid arrangements provide an important outlet for surplus production.

Ammonium sulphate accounted before the Second World War for the bulk of United States fertilizer nitrogen exports but by 1948 had been overtaken by ammonium nitrate. At that time shipments abroad represented one-third of total production of ammonium sulphate as opposed to nearly one-half of that of ammonium nitrate. As a substantial proportion of shipments were directed to temporary markets in Europe, opened by the lack of domestic supplies due to war damage to production facilities, the preponderance of ammonium nitrate was short-lived. To-day ammonium sulphate, with over 40% of its production exported, is again responsible for the bulk of United States shipments and ammonium nitrate takes second place, followed by urea, anhydrous ammonia, nitrogen solutions and complex materials. Although to date the growth of United States exports of fertilizer grade urea is by no means commensurate with its rising production, they are nevertheless assuming steadily increasing importance, particularly in respect of shipments to Asia.

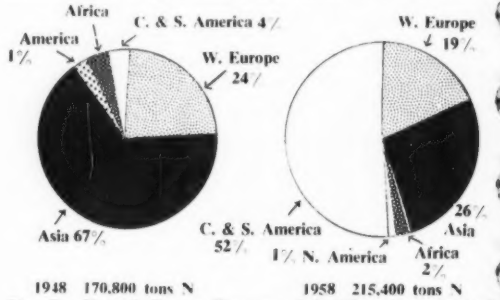


Fig. 7. United States. Exports of fertilizer by principal destinations.

Alternating as the principal outlet for United States fertilizer nitrogen, Asia and Central and South America have together taken over 75% of all shipments for the last eight years. Although United States supplies have met with stiffening competition from Europe and Japan in Asian markets in recent months, their position in Central and South America has improved. From a geographical standpoint alone this area would appear to be the natural outlet for North American surplus.

Japan

1958 237,900 tons N (68% AS. 26% U. 6% Others)

An outstanding feature of the post-war development of international trade in fertilizer

nitrogen has been the growth of Japanese exports. Playing only a minor rôle in the 1930's they are now at an annual level of nearly 240,000 tons N and account for 12% of the world total, the second largest in 1958. Originally created to meet the considerable demands of her domestic market, the Japanese nitrogen industry has, since the war, penetrated progressively further into South-East Asia to find outlets for its surplus production. In common with Japanese industry as a whole, it has adopted an aggressive sales policy but has nevertheless failed to prevent a progressive accumulation of stocks which at present are reported to total 200,000 tons N.

Ammonium sulphate, which until 1955 accounted for over 90% of all Japanese nitrogen fertilizer shipments, still accounts for over 60% but is rapidly losing ground to urea. Shipments of this material have increased from 1,800 tons N to 120,000 tons N in six years and promise to play a still more important, if not the dominant, part in Japan's exports of fertilizer nitrogen. It is difficult to avoid the conclusion that all urea capacity installed in Japan since 1956 has been erected primarily to exploit opportunities in foreign markets.

Changing Markets

Political as well as economic pressures have brought about considerable changes in the export markets for nitrogen fertilizers during the last 30 years. Europe, for long the principal recipient of exports, in 1928 absorbed over 40% of the world total. To-day, her capacity having increased over 4½ times, her share of imports has fallen below 30%. The emergence of Eastern Europe as a virtually self-sufficient block has also contributed to the lesser importance of European imports. North America has, despite a spectacular growth in her consumption from one-quarter to two million tons in 40 years, reduced the level of her imports by one-half and now receives less than 10% of the world supplies as against 33% in 1928.

Total Imports Received

	1928	*1938*	*1948*	*1958*
	000 tons N			
Europe ...	470,000	276,000	233,000	544,000
Asia & Oceania	141,000	104,000	180,000	757,000
Africa ...	39,000	46,000	89,000	117,000
North America	276,000	145,000	163,000	164,000
C. & S. America	18,000	37,000	74,000	420,000
World Trade	**944,000**	**608,000**	**739,000**	**2,002,000**
Consumption				
	000 tons N			
Europe ...	1,135,000	1,218,000	1,160,000	3,500,000
Asia & Oceania	231,000	208,000	405,000	1,500,000
Africa ...	40,000	47,000	95,000	255,000
N. America	503,000	500,000	966,000	2,200,000
C. & S. America	56,000	40,000	80,000	508,000
Total	**1,965,000**	**2,013,000**	**2,706,000**	**7,963,000**

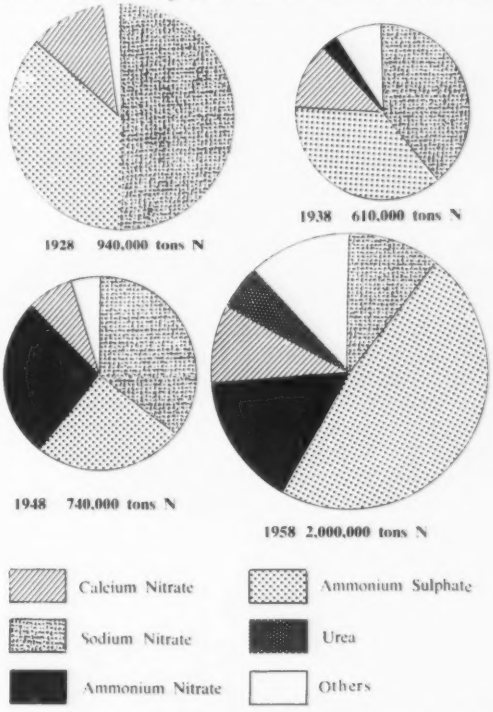


Fig. 8. Total World Exports of Nitrogenous fertilizer showing principal materials.

Since World War II the focal point of world trade has shifted to Asia which has quadrupled the volume of her imports and now accounts for almost 40% of the total. Central and South America, and to a lesser extent Africa, have also taken a larger share of supplies. Within Asia, China has emerged as a principal market, with imports in 1958 exceeding 320,000 tons N, of which 32% was supplied by Belgium, 28% by West Germany, 20% by Japan, 12% by Italy, and the balance by the Netherlands. After China,

South Korea ranks second among Asian markets with a total of 186,000 tons N in 1958, much of it supplied under foreign aid agreements. Taiwan, with 90,000 tons N, and India, with 50,000 tons N, in 1958 remained important markets for foreign supplies in spite of their growing domestic production.

Outlook

During the last 10 years the volume of world trade in terms of fertilizer nitrogen has risen from ¾-million tons N to 2 million tons N, whilst in the same period consumption has risen from just under 3 million tons N to 8¾ million tons N.

Despite the continuing growth of fertilizer nitrogen trade its importance in relation to world supplies is likely to decline during the next decade. Even in Asia, where in recent years imports have played the dominant part, this trend can be expected to assert itself before 1962. The installation, planned or already in progress, of 750,000 tons of nitrogen capacity in India, 110,000 tons in Pakistan, 100,000 tons in South Korea, 50,000 tons in Indonesia and 40,000 tons in Taiwan is designed to give these countries self sufficiency by 1965. China's plans to double her domestic production within this period are inspired not only by her determination to increase her consumption but by a desire to achieve progressive independence from imports. Thus within Asia as a whole despite enormous potential growth of consumption, the increasing availability of indigenous supplies reduces the prospect for imports. In particular Japan, who relies on this outlet for the disposal of virtually all her excess production, can be expected to turn to other markets.

In Central and South America, as in Asia, the potential growth of consumption is considerable but again, in the interests of national prestige or on economic grounds alone, it is planned to meet the bulk of anticipated demand with domestic production. At present work is in progress on the installation of some 350,000 tons of fertilizer nitrogen capacity. The logical outlet, from the geographical standpoint, for North American surplus production, this marketing area promises to become increasingly competitive. In North America, despite the anticipated expansion of demand, the availability from additions to installed capacity makes it unlikely that the present level of imports will increase. In Africa where, as in Asia and in Central and South America, potential demand is great, the capital necessary for agricultural development is becoming available too slowly to raise fertilizer demand above the level of domestic production planned for 1962. Capacity in operation, under construction or planned on the African continent, amounts to 420,000 tons N and of this nearly one-half will be located in Egypt, denying an important outlet for European supplies. In addition to the substantially increased capacity in Egypt, that in other Middle Eastern countries will exceed 110,000 tons N by 1965. Within Europe itself a considerable measure of capacity is to be installed in the major importing countries such as Spain, Portugal, Greece and Yugoslavia, with the primary object of reducing their dependence on foreign material.

The projected installation within the next five years of 2¼ million tons of new nitrogen capacity in 24 countries which in 1958 together imported 1 million tons N, or one-half of the world export total, cannot fail to have a disrupting effect on the pattern of exports. This situation is aggravated by the concurrent installation of additional capacity totalling 600,000 tons N in the 10 major exporting countries, where capacity already appears to be well in excess of their growing domestic requirements and which will thereby add to the export surplus. Already prices by European exporters have declined by over 10% in the past two years.

Under these conditions many technical improvements and further rationalization of the nitrogen industries in major exporting countries are being effected. Comprising some of the world's most progressive and powerful chemical manufacturers, the Nitrogen Industry can be expected to avoid the pitfalls which might inflict serious injury arising from short term adverse conditions and to take measures conserving its strength and ability to serve world markets, the long term prospects of which are strong.

Supply · Trade · Prices

WORLD SUPPLIES of nitrogen are estimated to have expanded in the recently terminated fertilizer year 1958/59 by at least 7%. During the spring fertilizer season in the Northern Hemisphere, especially in the U.S.A., deliveries rose to unexpected levels, and this is responsible for the improvement of the market sentiment at present in evidence in the U.S.A. From the viewpoint of W. European producers, nitrogenous fertilizer markets are quieter, and the outlook for the immediate future is one of apprehension. This applies especially to those European producers who are dependent to a disproportionate extent on outlets in Asian markets, partly because of the weaker demand, and mainly because of mounting pressure of the Japanese export surplus of ammonium sulphate and urea. In Eastern markets and others farther afield where Japanese competition has become determined, the prospect of securing part of the market is becoming more remote. In consequence there is growing instability in a number of overseas markets, notably in Africa and South America, where attempts of some suppliers to obtain a share of often quite small import requirements has sharpened competition.

In Japan the growth of stock-piles is causing alarm and following the modest increase in the level of most European producers' stocks in the Spring, this is once more mounting. Owing to lesser gas and cokeoven activity by-product ammonium sulphate output in W. Europe has receded and stocks are not too excessive. Ammonium nitrate and lime ammonium nitrate, however, are in over-production and stocks are heavier than at this time last year.

Since the termination of the spring fertilizer season, the improvement of employed capacity in U.S.A., Japan and W. Europe was not maintained and it is now estimated at about 80%. The anticipated world expansion of plant capacity during the coming fertilizer year is 700,000 tons N, representing about 7% of installed capacity. A significant proportion of this is in the form of urea. There is no change in the present trend of recent years of the fast advance of nitrogen consumption compared with that of other plant nutrients.

In the **U.S.A.** production of anhydrous ammonia during the first six months of 1959 rose to peak levels and production in May of 342,000 tons N. is the highest on record. U.S. plant capacity now exceeds 5,000,000 tons per annum NH_3, which it appears was almost fully employed during peak production of April and May. As a result of the intensive activity of the steel industry prior to the strike, by-product ammonium sulphate rose to an annual rate of over 850,000 tons, about 50% more than during the spring of 1958. Following the high level of output of nitric acid in April and May when it rose to nearly 270,000 short tons (100% HNO_3), fertilizer manufacturers reduced operations; consistently good industrial demand is being met from adequate stocks.

A measure of the impact made by the exceptional Spring fertilizer demand is the decision of one urea manufacturer to cut off all exports for the coming year, to avoid a repetition of the experience of several producers of having to turn to competitors for spot supplies of ammonia and solutions.

A notable feature of the past fertilizer season has been the rapid increase of straight nitrogen application, notably of solutions, in contrast with the prevailing trend in the use of potash and phosphorus which shows the greater advance in mixtures and complexes.

Construction has started of the $8 million urea plant which SunOlin are building at North Claymont, Del., employing the Montecatini process—the fourth plant in the U.S.A. to do so. It will have a capacity of 73,000 tons annually of prilled grade for fertilizer and industrial use, special prills for cattle food and a high purity crystalline foliar grade for spraying. Due to come on stream in October is the $9.5 million fertilizer plant at Helm, Calif., which has facilities for the manufacture of 150 tons daily of anhydrous ammonia, 200 tons sulphuric acid, 200 tons ammonium sulphate and 240 tons ammonium phosphate.

In **Japan** the serious deterioration of the supply position, manifested by stocks of nearly 200,000 tons N., is the result of excessive production and inability to place the export surplus. It is expected that for the current fertilizer year the Government will recommend that production is reduced by about 10% compared with the previous plan. At the level of installed capacity on 1st August of about 1,000,000 tons N., the rate of employment of plant is about 80%. It is foreseen that during the current year, of the total anticipated production of 846,000 tons N., ammonium sulphate will account for about 63%, urea 25%, and the balance represented by ammonium chloride, ammonium nitrate and high-grade compound fertilizers. The proposed level of exports is 356,000 tons N, of which about 60% is to be ammonium sulphate and 34% urea. The industry fears that the reduction of production will cause costs to increase. If, to compensate for this, domestic prices were increased, this might result in a further reduction of domestic sales. Proposals placed before the Government suggest the inclusion of ammonium sulphate and urea, to the greatest possible extent, amongst the commodities being supplied under Reparation agreements, possibly to the Phillipines or to Indonesia. The possibility is also being reviewed to make fertilizer export deliveries on credit or deferred payment terms.

In the **United Kingdom** imports during the first half year 1959 advanced to 160,000 tons nitrogenous fertilizers. It is estimated that this tonnage included 90,000 tons ammonium sulphate. In this respect Imperial Chemical Industries Ltd. have lodged an application with the Board of Trade to ban further imports of this material on the grounds that the level of the import prices was tantamount to dumping. Exports of U.K. ammonium sulphate during the same period totalled 64,500 tons, destined almost exclusively to Commonwealth countries.

On the **Continent of Europe** there are some indications of curtailment of activity and employment of installed capacity in W. Europe, estimated at 3.8 million tons N., following the closure in May of the 50,000 tons per annum N plant of Krupp, has receded. This is particularly in evidence in respect of by-product ammonium sulphate operations in W. Germany and Belgium. In consequence stocks of ammonium sulphate have not accumulated as rapidly as those of lime ammonium nitrate. The 70 tons per day urea plant of Soc. Carbochimique at Tertre successfully entered operation in July. Urea installations are reported to be under construction at Soulom, France, and at Esterreja in Portugal. A loan of $7.6 million has been granted by the U.S. Export-Import Bank to Abonos Sevilla S.A. who will now realise their plans for the first major nitrogenous fertilizer plant in the South of Spain.

In **Eastern Europe** and the **U.S.S.R.,** plant projects with an aggregate capacity of about ½ million tons N. have been announced; their completion dates are mostly to be in 1961, but some, like the 140,000 tons N. works at Sala, Slovakia, are not due on stream until 1965.

Demand from markets in the **Middle East** and **Far East** is at present quiescent. China, the principal factor in the European export trade, is now reported to have augmented her purchases by nearly 50% from the levels in May and June to nearly 300,000 tons N., comparing favourably with the tonnage bought during the preceding year. The earlier tendency of placing orders at the beginning of the fiscal year appears to be giving way to piecemeal purchases to take advantage of the weak market.

Further tender invitations in June and July advanced the level of I.C.A. purchases for South Korea. Emphasis is on ammonium nitrate, lime ammonium nitrate and ammonium sulphate nitrate.

The award of a tender for the supply of urea to Pakistan in June went to Japan to the extent of 5,700 tons. India is going into the market shortly for about 60,000 tons N, expected to be in the form of:

Ammonium Sulphate	108,000 tons
Ammonium Sulphate Nitrate	41,800 tons
Calcium Ammonium Nitrate	41,000 tons
Urea	39,800 tons
Nitro Phosphate	10,000 tons

Japanese suppliers are likely to succeed in all ammonium sulphate, urea and perhaps also nitro phosphate contracts at prices which may well prove to be the lowest ever.

FREIGHT

Continued weakness of the freight markets depressed the voyage index of the U.K. Chamber of Shipping from 64.6 in May, but in July it had recoverd slightly to 69.2. Separate rate trends are emerging for Liberty-size vessel and for larger vessels in excess of 12,000 tons. An indication of current rates for vessels of 10,000-12,000 tons is as follows :

To	*From*		
	Japan	*U.S.A.*	*W. Europe*
China	—	—	51s. 6d.
India (W. Coast) ...	$6.50	—	48s. 6d.
" ...	35s.		
Central America ...	—	$13	30s.
East Africa	—	—	40s.
South Korea ...	$2.75	$9	51s. 6d.

PRICES

The world price structure is unstable, but at present there is no sign of a general decline in prices. The absence of offers of U.S. material helps to promote a steadier tone. In specific markets, as in some African countries, in South and Central America and in Yugoslavia, offers of relatively small tonnages at very low prices have radically changed the earlier picture and now prices are in a state of collapse. The liberalisation of imports of nitrogenous fertilizers into Spain is expected to result in the termination of purchases by tender. The outlook for the fertilizer year which has just started is uncertain and suppliers are apprehensive.

Domestic Prices

With the exception of the U.S.A., where the domestic price structure is competitive with world export markets, the domestic markets of the major producers are supported by price subsidy. In most of the latter there has been a modest reduction of prices, whereas in the U.S.A. market firmness has caused some price advances.

U.S.A.

Following the conclusion of an exceptionally favourable fertilizer season some prices advance and the seasonal reductions of price schedules were not as great as last year. Ruling prices are as follows :

Coke-oven ammonium sulphate
$32 per short ton f.o.b. in bulk
Synthetic ammonium sulphate
$35 per short ton f.o.b. in bulk
Ammonium nitrate (33.5% N)
$57 per short ton f.o.b. in bulk
Ammonium nitrate (33.5% N)
$63 per short ton f.o.b. in bags
Calcium Cynamide
$57 per short ton f.o.b. in bags
Nitrogen solutions (40.8% N.; basic 100%)
$120 per short ton f.o.b.

The price of lime ammonium nitrate, calcium ammonium nitrate and sodium nitrate, advanced $2.50 per ton to $44 per ton f.o.b. works. Bagged material in car load lots is $4 per ton more. Nitrogen solutions in the fourth quarter will be $124 and on the 1st January will be advanced to $128. Anhydrous ammonia fertilizer grade is quoted at $84 per short ton in tanks, and refrigeration grade $6.50 dearer. Heavy demand for fertilizer grade is reflected in firm prices for ammonia for industrial uses. The outlook in both sectors of this market are considered better than for many years past.

United Kingdom

Imperial Chemical Industries Ltd. announced that from 1st July the price of ammonium sulphate manufactured by members of the British Sulphate of Ammonia Federation would be reduced to £19 17s. 0d. before deduction of the subsidy, or 11s. lower than the previous July. The current price is £20 0s. 6d. for minimum 6 ton lots and will rise by monthly increases of 3s. 6d. to reach £21 5s. for the period March/June 1960. The guaranteed nitrogen content of ammonium sulphate has been raised from 20.8% to 21% N. The price of Nitro-Chalk "Twenty-One" was reduced from £24 8s. 6d. to £24 a ton as from 1st July. Prices of other nitrogen fertilizers sold by Imperial Chemical Industries remain unchanged. The Shell Chemical Company reduced the prices of " Nitra-Shell " 23 and Magnesium " Nitra-Shell " by 10s. per ton from 1st July. Before deduction of the subsidy the current prices for 6 ton lots delivered to the nearest railway station are £26 5s. 0d. for " Nitra-Shell " 23 and £26 18s. 6d. for Magnesium " Nitra-Shell."

Current quotations of United Kingdom nitrogenous fertilizers delivered to the farmers' nearest railway station are :—

	Per ton	*Subsidy*
Ammonium sulphate (21% N) ...	£20 0 6	£9 19 6
Nitro-Chalk (15.5% N)	£18 10 0	£7 7 3
Kaynitro (16% N)	£26 17 6	£7 12 0
Nitra-Shell (23% N)	£26 5 0	£10 18 6
Magnesium Nitra-Shell (20.5% N)	£26 18 6	£9 14 0
Sodium nitrate (16% N) ...	£26 10 0	£7 12 0

The application for the removal of the U.K. import duty of £4 per ton ammonium sulphate awaits a decision pending further enquiries by the Board of Trade.

WESTERN GERMANY

For the fertilizer year 1959/60 the following prices have been posted by the principal producing companies :

	DM per tonne N				
	Sept.-Oct.	Nov.	Dec.	Jan.	Feb.-June
Ammonium sulphate (21% N) ...	1,130	1,140	1,150	1,170	1,190
Ammonium sulphate nitrate (26% N)	1,140	1,150	1,160	1,180	1,200
Lime ammonium nitrate (20.5% N)	1,160	1,170	1,180	1,200	1,225
Calcium nitrate (15.5% N) ...	1,300	1,310	1,320	1,340	1,360
Sodium nitrate (16% N) ...	1,350	1,360	1,370	1,390	1,400
Urea (46% N) ...	1,130	1,140	1,150	1,170	1,190

There have been some reductions compared with the preceding year; they include the prices of BASF for calcium nitrate, and for urea and the new price, as shown above, narrows the former differential of the cost of N. in various materials. It is not expected that urea sales will rise appreciably following this reduction, as this product does not yet command general favour with the German farmer.

Ammonium Sulphate

Current quotations in export markets range from about $33-37 per tonne f.o.b. in bulk, although some distressed sales of parcels at a lesser price have been reported. Material in bags is quoted by Western European suppliers at about $39 per tonne f.o.b. The tender award in June in Korea quotations for 184,700 tonnes ranged from $37.50 to $53.02 per tonne f.o.b. European suppliers in the lower price bracket, U.S., Canadian and Japanese suppliers secured approximately equal shares.

Ammonium sulphate nitrate, not prominent in markets recently, continues to show a slight advantage in comparison with the unit price of ammonium sulphate but not with lime ammonium nitrate.

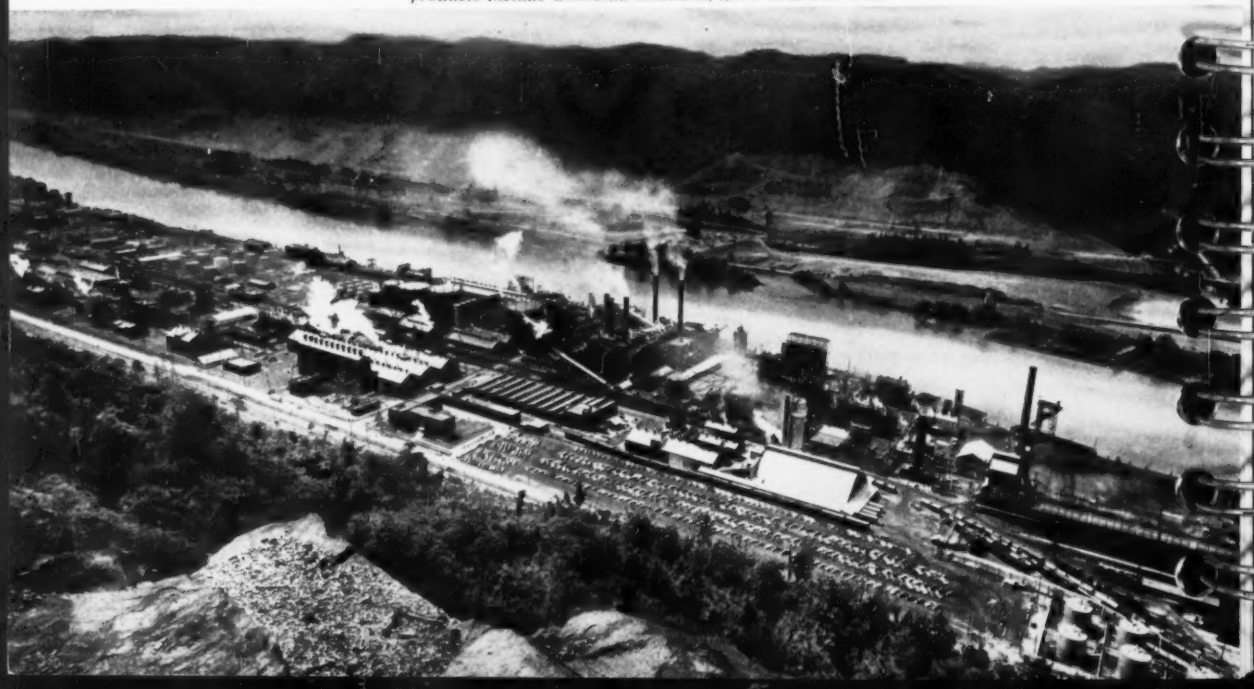
Ammonium Nitrate

Abundant supplies in excess of demand keep prices by W. European supplies to about $60-62 per tonne f.o.b. in bags. Offers at Yugoslave and Bulgarian supplies are again reported. At the tender in June in Korea bids for 86,500 tons of ammonium nitrate ranged from $54.91 to $65.11 per tonne f.o.b.—all U.S. and Canadian supplies. Satisfactory progress is reported in negotiations between Austria and Brazil for the barter of coffee—initially some 100,000 bags already lying at Trieste—against Austrian plant and nitrogenous fertilizers, probably lime ammonium nitrate.

Urea

Rising supplies are exerting pressure on prices. In W. Europe prices range from $82-84 per tonne f.o.b. in 5-ply bags with polythene linings. Japanese urea is reported on offer freely at $85 per tonne f.o.b. stowed and also less, although not yet below $80 per tonne.

General view of the du Pont Company's Works at Belle, W.Virginia. One of the largest Nitrogen plants in the U.S.A., products include ammonia solutions, nitric acid and urea.



THE NITROGEN INDUSTRY IN AUSTRALIA

THE DEVELOPMENT of fertilizer nitrogen consumption in Australia, now at a level of 33,000 tons a year, has been slow. Current supplies are almost exclusively (90%) in the form of ammonium sulphate, the bulk of which is of domestic origin. At present fertilizers are seldom used in Australia in areas where the annual rainfall is less than 15" except where irrigation is employed. Consequently most fertilizer consuming areas are located in a belt up to 250 miles wide extending along the East and South-East coasts, in the South-West corner of Western Australia and in Tasmania. The greater part of agricultural soils is deficient in sulphur and phosphorus, and superphosphate is therefore the principal material used. Chemical nitrogen fertilizers are not widely used as it is the practice to rely on legumes to provide much of the soil's nitrogen requirements. This is estimated to total 70lb. N per acre per annum and it is considered that in few arable or pasture lands this quantity is consumed. In the sugar plantations of Queensland, however, there is a substantial nitrogen demand and this applies also to some of the intensively cultivated areas near the major towns. On the sugar crop ammonium sulphate is extensively used, whilst mixed fertilizers are applied chiefly for horticultural purposes.

Consumption

In Victoria ammonium sulphate meets virtually all the demand for nitrogen fertilizer although it is used on a much smaller scale than superphosphate with sales totalling about 16,000 tons a year. In Western Australia only 6,000 tons of ammonium sulphate were sold in 1957/58 and the demand for mixtures is as yet negligible.

As in Western Australia, consumption of nitrogen fertilizers in South Australia is low and only 9,000 tons of ammonium sulphate were sold in 1957/58. In New South Wales the use of legumes to provide nitrogen is on the increase and the quantity of ammonium sulphate sold straight and in mixtures does not exceed 15,000 tons a year. On the other hand, the popularity of urea for use in complete fertilizers for the small crop farmer and home gardener is growing steadily.

In Queensland some 76,000 tons of ammonium sulphate were sold straight and in mixtures, the bulk of it for use on the sugar crop, whereas vast areas of land under wheat received no fertilizer at all.

In Tasmania there is also an important potential growth in nitrogen fertilizer application but in 1957/58 not more than 3,000 tons of ammonium sulphate were sold straight and in mixtures. In all States the small scale use of sodium nitrate is in evidence and the demand for urea appears to be rising.

Production

There are at present six firms manufacturing nitrogen fertilizers in Australia and production capacity, entirely in the form of ammonium sulphate amounts to approximately 125,000 tons a year. As all six firms are located in the states of New South Wales, Victoria and Tasmania, there is a substantial interstate trade, particularly with Queensland.

Production of Ammonium Sulphate in Australia

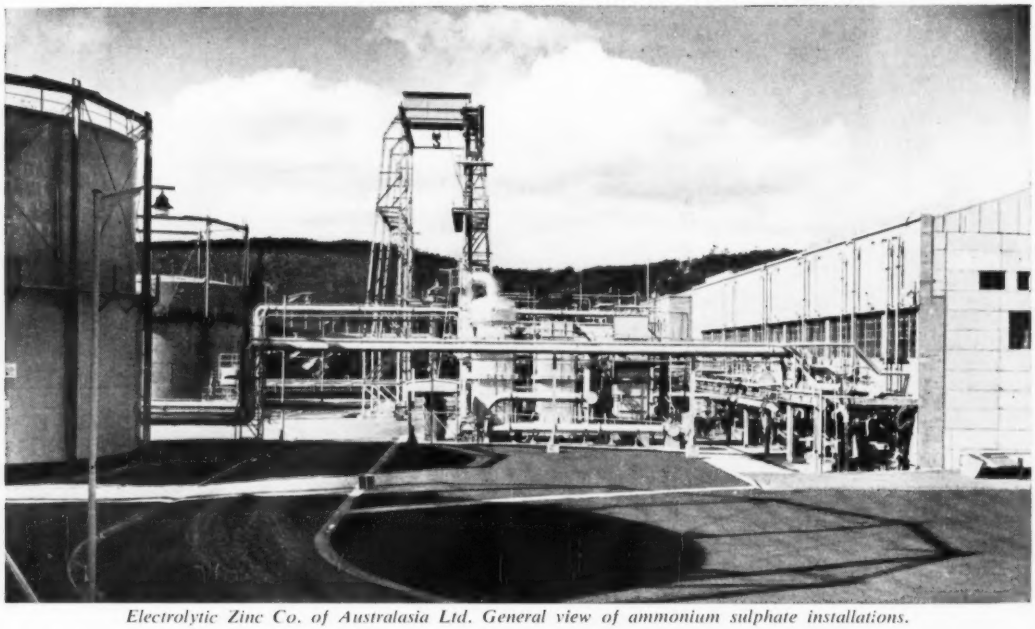
Year	*tons*
1938/39	24,300
1945/46	21,800
1948/49	53,200
1951/52	63,800
1954/55	78,400
1957/58	118,700

Prior to November 1956, with the exception of two Government plants which produced ammonia and ammonium sulphate during World War II, the only ammonium sulphate produced in Australia arose as a by-product in steel and gas works. Since then, however, manufacture of synthetic ammonium sulphate has been undertaken at Risdon, Tasmania, by the Electrolytic Zinc Company of Australasia Ltd. Nitrogen is obtained by fractional distillation and as a by-product of zinc refining operations, while hydrogen is obtained by electrolysis. The capacity of the Risdon works exceeds 50,000 tons of ammonium sulphate a year.

Other ammonium sulphate producers, all operating in New South Wales, are the Australian Gas Light Co. with works at Mortlake, near Sydney, Australian Iron and Steel Ltd. at Port Kembla, the Broken Hill Pro-

prietary Co. Ltd. at Newcastle, and the Government works at Mulwala. In Victoria ammonium sulphate is manufactured at the Government works at Albion near Melbourne and at Ballarat.

The production of mixed fertilizers, now at an annual level of 330,000 tons, has risen by 65% in the last seven years and it is estimated that over half the ammonium sulphate sold in Australia is used in their manufacture.



Electrolytic Zinc Co. of Australasia Ltd. General view of ammonium sulphate installations.

Imports

The expansion of domestic ammonium sulphate production has, of course, reduced Australia's dependence on imports of this fertilizer. Nevertheless, some 20,000 tons was imported in 1957/58, all of which was purchased from the United Kingdom. In the previous year over 99% of imported sulphate came from West Germany while in 1955/56 the United Kingdom supplied 97% of the total.

Australian Imports of Nitrogen Fertilizers (tons)

	ammonium sulphate	sodium nitrate	other
1938/39 ...	35,503	10,183	91
1954/55 ...	35,055	11,714	260
1955/56 ...	9,466	14,102	386
1956/57 ...	28,251	11,219	17
1957/58 ...	19,708	14,430	2,121*

* mainly urea.

Virtually all sodium nitrate imports are obtained from Chile, whilst the bulk of urea supplies originate from Japan.

Rockhampton

Considerable attention is at present focused on the projected nitrogen fertilizer plant at Rockhampton in Queensland where it is planned to use pyrites concentrates from the Mount Morgan mine about 25 miles distant to produce annually up to 100,000 long tons of ammonium sulphate or ammonium phosphate. Hydrogen for ammonia synthesis could be obtained from nearby lignite deposits and power and good transport facilities are also available.

According to one of the estimates for this project the Rockhampton plant would cost £5.3 million and ammonium sulphate could be produced at approximately £10 less than the current price of imported material. Queensland would not only become independent of imports but a greater volume of domestic supplies would be available in other parts of Australia. It is, however, still possible that a decision may be taken to produce ammonium nitrate or

urea at Rockhampton in addition or as an alternative to ammonium sulphate.

Outlook

Although no spectacular rise in demand for nitrogen fertilizers can be expected in Australia in the foreseeable future there is room for increased consumption, particularly in New South Wales, Tasmania and Queensland. If Australia is to support a population of over 10 million and at the same time maintain exportable surpluses of agricultural products, more intensive use will have to be made of land already farmed and new areas must continue to be brought under production. This will only be achieved by greater use of fertilizers, and although the practice of providing much of the nitrogen required by the soil from legumes is likely to prevail, there is scope for the increased use of chemical nitrogen on both arable and pasture land.

Whereas ammonium sulphate is likely to remain the principal nitrogen fertilizer used in Australia for several years to come, urea can be expected to become increasingly popular particularly in view of the advantages afforded by a high analysis material when, as in Australia, transport over long distances is involved. In addition there is scope for the use of urea as an animal feed and experiments are currently being conducted in Australia on its ability to promote greater wool yield. Urea should also find a valuable outlet in Australian industry.

NITROGEN IN FRANCE

EXPANSION AT SOULOM

THE SOULOM WORKS of the Societé Générale d'Engrais et des Produits Chimiques " Pierrefitte " is situated in the Hautes Pyrenées Department, 12½ miles south of Lourdes on the bank of the river Pau. Built in 1916 to use hydro-electric power in the production of synthetic nitrogen for miltary purposes, the plant employed the Arc Process until 1925 when this method was abandoned in favour of ammonia synthesis from electrolytic hydrogen.

The plant installed in 1925, some sections of which are still in service, consisted of a 40 tons per day Casale ammonia synthesis unit operating at 11,400lb. per sq. inch, a nitric acid unit employing Bamag burners for oxidation and four granite absorption towers; in addition there were installations for the manufacture of sodium nitrate and calcium nitrate, considered at that time to be the nitrogen fertilizers with the greatest potential. Hydrogen was produced by four Knowles cloche type batteries and three Pechkranz filter press batteries connected to 3,800 KWh generators.

The expansion of the Soulom plant to its present capacity is a comparatively recent development, having taken place within the last 12 years. When the price of electricity made the production of electrolytic hydrogen uneconomic, conversion to natural gas and subsequent extension of the plant on the basis of this source of hydrogen was made possible by the discovery of reserves of natural gas in south-western France in 1942 at Saint Marcet, near Saint Gaudens, and 10 years later at Lacq.

Of necessity, the new installations employ very different methods from those formerly used : separation of oxygen from natural gas, carbon dioxide extraction and purification with water and ammoniacal copper carbonate at pressures of 425 and 4,250lb. per square inch.

With the installation of new plant, the production capacity of the Soulom works was raised by stages to 90 tons of ammonia a day in 1956. At the same time two nitric acid units, oxydizing at a pressure of 36lb. per square inch were built as well as additional fertilizer plant, while, simultaneously, at the nearby Pierrefitte works a plant to produce 200 tons a day of " ammonitrates " (20.5% N) was installed.

A new stage in the development of the Soulom factory now in progress will raise the capacity of the ammonia installations to 240 tons a day by 1960. A section of this expansion

General view of the works at Pierrefitte and Soulom in the Pyrenees foothills.

programme has already been completed and ammonia production now exceeds 125 tons a day. When the current extensions have been completed the works will comprise the following installations:

Ammonia Synthesis. Two oxygen separation units, one operating at low pressure, the other at 42.5lb. per square inch, with capacities of 40 and 90 tons a day respectively. A steam reforming unit operating at 42.5lb. per square inch with a daily capacity of 110 tons. Three groups of carbon dioxide purifiers working at a pressure of 425lb. per square inch employing a potassium arsenite solution (Vetrocoke Process). Two groups of carbon dioxide purifiers working at a pressure of 4,250lb. per square inch, using ammoniacal copper carbonate. A 180 tons per day medium pressure synthesis plant employing the Fauser-Montecatini Process with gaseous recycle. This unit is already in service. The older Casale type plant which will continue to operate at a reduced level of capacity.

Nitric Acid. A unit with a capacity of 40 tons per day (in terms of ammonia) will be added to two 30 tons per day oxydizing plants working at a pressure of 285lb. per square inch, and a 15 tons per day concentrated acid plant.

Nitrogen Products. A 120 tons per day urea plant will be added to the existing installations at Soulom. This plant, which will employ the Fauser-Montecatini process with partial recycle is now under construction. At the same time the Pierrefitte works will be expanded and capacity raised to 260 tons of ammonium nitrate a day, based on the use of ammonia off gases from the urea plant or directly from the ammonia synthesis units. In addition, there are facilities for the manufacture of ammonium phosphate.

By the spring of 1960 the works at Soulom and Pierrefitte will be capable of an annual production of 70,000 tons N to be used in the manufacture of calcium nitrate, magnesium nitrate, ammonium nitrate, ammonium phosphate and urea. This will represent some 14% of the total capacity of the French Nitrogen Industry of which over half continues to be based on the use of coke and coal. With the increasing employment of natural gas, the Industry will progressively improve its ability to meet the growing requirements of the domestic market in the face of rising competition from other producers within the Common Market area.

LAKE CHARLES, LOUISIANA - AMMONIA FROM REFINERY WASTE GASES

WITH A CAPACITY of 305 short tons a day the ammonia synthesis installations at Lake Charles, La., were commissioned by Petroleum Chemicals Inc. in February, 1958. Labour troubles held up the completion of this project for a considerable time but once in operation the plant has performed with a high degree of efficiency. Built by Foster Wheeler Corporation, this important Casale type plant uses hydrogen in the waste gases from three different dehydrogenation processes: Platforming in the Continental Oil Company's refinery, hydroforming in the adjacent Cities Service refinery and from the butadiene plant operated by Petroleum Chemicals Inc. These gases contain different percentages of hydrogen and different impurities.

COMPOSITION OF FEED GASES

Feed Gas	Million cu. ft. per day	(per cent) H_2	N_2	CO_2	CO	C_1+	(ppm) C_2H_2	H_2S
Waste gas from:								
Platformer ...	... 5.5	90.4	.2	10 ppm	.1	9.3		500
Hydroformer	... 23.5	64.5	2.4	.1	.1	32.9		10
Butadiene plant	... 2.0	74.6		13.9		11.5	200	

Because of their low carbon dioxide content, the hydroformer and platformer waste gases are preferred as feed gases, the waste gases from the butadiene plant being used to make up the necessary volume.

The removal of impurities and recovery of pure hydrogen from these combined gases is accomplished by chemical treatment, low temperature fractional condensation and by selective absorption in liquid nitrogen with an atmospheric boiling point of −320°F, a temperature below the boiling point of carbon monoxide, −313°F, the lowest boiling point of any of the impurities.

Purification

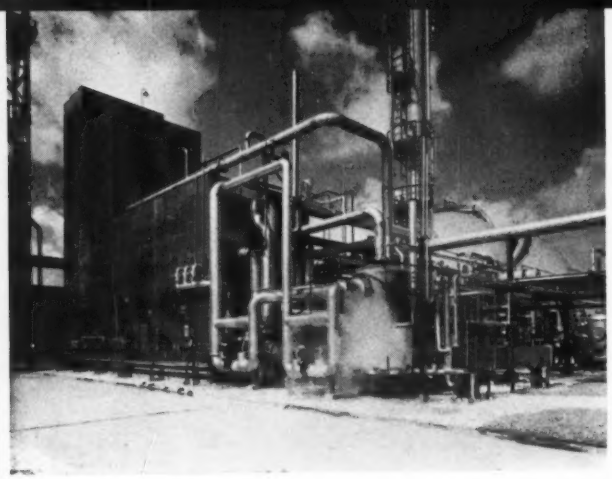
The three feed gases are separately compressed to 400 p.s.i., with the hydroformer and butadiene waste gases being then cooled and fed to the carbon dioxide absorber where carbon dioxide is removed in monoethanolamine solution. This solution flows from the absorber to a reactivator where carbon dioxide is stripped off, the reactivated solution being recycled. The gas from the absorber joins the compressed platformer feed gas and the combined stream of the three gases then enters the caustic scrubber where traces of carbon dioxide and H_2S are removed. The purified gas is then chilled, dried and fed to the low temperature separation unit.

Low Temperature Separation

Fractional condensation and absorption in liquid nitrogen separates the purified feed gases into four separate streams; methane for plant fuel, ethane for ethylene production, carbon dioxide which is exhausted and a 99.9% pure hydrogen-nitrogen stream for ammonia synthesis.

Air Separation

Air is caustic washed, chilled, dried and separted into oxygen and 99.9% pure nitrogen. The oxygen is at present vented, but a study is being made of the economic feasibility of using it to accelerate catalyst regeneration in fluid catalytic cracking units in the adjacent Cities Service refinery. Part of the nitrogen is compressed in three stages to 390 p.s.i. and is added to hydrogen-nitrogen stream from the low temperature separation unit to obtain a feed gas with the molar ratio of 75% hydrogen and 25% nitrogen required for



Petroleum Chemicals Inc., Lake Charles, La. Liquid nitrogen wash tower, exchangers, receivers, etc., of low temperature separation unit, completely enclosed in insulated structure.

synthesis of ammonia. The remainder of the nitrogen is compressed in two more stages to approximately 3,000 p.s.i. and enters the low temperature separation unit where some of it is liquified and used to absorb the light hydrocarbon gases and other impurities in the feed gas. The rest is used as a refrigerant in a closed system and is recirculated to the high pressure stages of the nitrogen compressor.

Ammonia Synthesis

The synthesis gas enters a multi-stage compressor and its pressure is raised to approximately 7,500 p.s.i. After cooling it is fed to the Casale ejector which functions as a recirculating unit for the unconverted nitrogen and hydrogen. (The once-through yield of anhydrous ammonia is approximately 25%, but practically all the feed gas is ultimately converted). The fresh synthesis gas from the compressor and the unconverted nitrogen and hydrogen recycle from the high pressure separator join into one stream in the ejector and enter the Casale reactor where the exothermic union of hydrogen and nitrogen is completed to produce ammonia.

The reactor installed at Lake Charles is the largest single high pressure reactor in the Nitrogen Industry. It is built of multiple layers and has a wall thickness of approximately 9 inches. It weighs 180 tons, exclusive of the catalyst and external fittings. The reactor serves not only as a catalyst container but as a heat exchanger to utilize the heat of the outgoing gases to preheat the incoming feed.

The ammonia vapour is condensed and, mixed with the recycle gas, enters the high pressure separator. The recycle gas flows to the ejector and the liquid anhydrous ammonia, under liquid level control, flows to the low-pressure separator. In this vessel any absorbed synthesis gas is flashed off and returns to an intermediate stage in the synthesis gas compressor. Liquid ammonia flows from this separator through an ammonia refrigerated chiller into a let-down drum. Here a small amount of ammonia is flashed off and recovered in a condenser using ethylene refrigerant. This material then joins the main body of the anhydrous ammonia product as it flows to storage at 35°F and 50 p.s.i.

Compressors

Six compressors are used to move the gases through the various sections of the process at the specified pressures. They are divided, in pairs, into three general service classifications: hydrocarbon gases, non-hydrocarbon gases and synthesis gas. The specific services in each compressor are shown in the following table:

Number	Stages*	Pressure (p.s.i.g.) Suction	Pressure (p.s.i.g.) Discharge	Service	H.P.
	1	100	415	Hydroformer feed gas	
	1	145	410	Platformer feed gas	3,000 each
2	2	40	415	Butadiene plant feed gas	
	2	0	235	Ethane & fraction from LTSU	
	1	0	90	Methane & fraction from LTSU	
	3	0	180	Air to air separation plant	
	2	0	240	Ammonia refrigeration plant	
2	2	0	440	Ethylene refrigeration unit	3,700 each
	3	0	390	L.P. nitrogen (blending)	
	2	390	2,960	H.P. nitrogen to LTSU	
2	4	330	7,500 (9,260 max.)	Synthesis gas	4,000 each
6	23				21,400

* Aftercoolers after each stage remove heat generated by compression

The compressors are motor-driven reciprocating machines with horizontal compression cylinders operating from a common shaft. Each compressor has a service capacity rating between 50% and 60%. When the plant is operating at design capacity all compressors are running and should any compressor be shut down for repairs, the processing capacity would have to be reduced to approximately 50%. The principle of using two 50-60% capacity compressors for a specific service, instead of one 100% unit and a spare, greatly reduces initial investment cost. It is feasible because the advance design technology and fabrication of modern compressors afford operating reliability over extended periods of time.

Instrumentation

The instrumentation at the Lake Charles plant is entirely pneumatic with miniature case instruments mounted on a graphic panel in the main control room. Instrumentation associated directly with the compressor installation is located at a central station in the compressor house. Automatic analyzers on this unit continuously indicate the content of acetylene and ethylene in the liquid oxygen reboiler, saturated and unsaturated hydrocarbons in the air, acetylene in the butadiene feed gas and hydrogen in the synthesis feed gas and high pressure recycle.

The Use of Refinery Waste Gases

An outstanding feature of the Lake Charles plant is the use of three different types of waste gas, presenting major technical problems in design, and the successful performance of the plant is a notable chemical engineering achievement.

The use of refinery waste gases as a source of hydrogen for ammonia production is already incorporated in over one-third of the total United States synthetic nitrogen capacity and is steadily gaining ground throughout the world. As, under most conditions, it constitutes the most economic basis for ammonia synthesis, it can be expected, with the continued expansion of refining operations, to account for a growing proportion of world nitrogen capacity.

AMMONIUM SULPHATE FROM PORT NICKEL

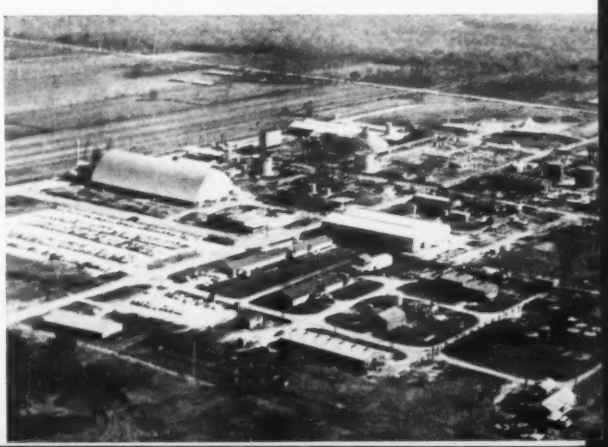
By-Product of Nickel-Cobalt Refining Operations

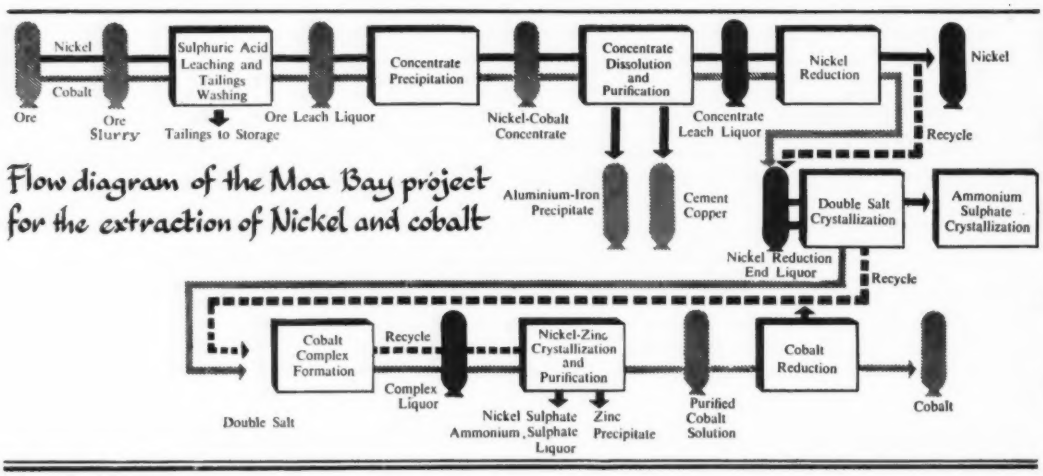
THE FREEPORT NICKEL COMPANY, a subsidiary of the Freeport Sulphur Company, the world's second largest producer of Frasch sulphur, will join the ranks of nitrogen fertilizer manufacturers when a major plant is commissioned at Port Nickel, Louisiana, early in 1960. 90,000 tons of ammonium sulphate a year will be obtained as a by-product of the new nickel and cobalt refinery which has an annual capacity of 50,000,000 pounds of nickel metal and 4,400,000 pounds of cobalt metal. The $119 million project will utilize lateritic nickel ores mined at Moa Bay in the east of Cuba and the ammonium sulphate will emerge as a by-product of the Chemico process used in the ultimate conversion of these ores to metal. At Moa Bay the nickel and cobalt content will first be leached from the ore with sulphuric acid and will then be precipitated as sulphides. A specially converted vessel will carry the sulphides, in the form of a slurry, to the refinery situated at Port Nickel, Louisiana. Here ammonium sulphate will be obtained at the two stages in the refining operations when nickel and then cobalt metal are consecutively separated.

Nickel Metal Separation

The first step in the refining process at Port Nickel is the oxidation of the nickel-

Aerial view of the Freeport Nickel Company's refinery at Port Nickel, Louisiana.





Flow diagram of the Moa Bay project for the extraction of Nickel and cobalt

cobalt sulphide slurry to a clear sulphate solution by treatment with compressed air and sulphuric acid. Iron, aluminium and chromium impurities are removed by precipitation with ammonia and filtration. Copper, lead and zinc impurities are then removed by precipitation with hydrogen sulphide gas and filtration.

The purified solution of nickel, cobalt and ammonium sulphate is treated with ammonia and hydrogen gas at high temperature and pressure to reduce the nickel ions to nickel metal which is then separated. The metal salts of cobalt and the remaining nickel are crystallized from the reduced solution, leaving aqueous ammonium sulphate.

Cobalt Metal Separation

The crystallized salts are dissolved in a concentrated ammonia solution which is treated with air under pressure to convert the cobalt into a soluble, stable compound. The solution is then treated with sulphuric acid to form ammonium sulphate, the remaining nickel being crystallized as nickel sulphate which is removed by filtration for recycle. The cobalt in the remaining solution is reduced to metallic cobalt by treatment with hydrogen under high pressure and temperature. After removal of the metal a solution of ammonium sulphate remains.

Purification of Ammonium Sulphate

The ammonium sulphate solution is treated with hydrogen sulphide for the removal of final traces of metal impurities, the purified solution being evaporated to yield ammonium sulphate crystals which are intended to compare favourably in quality with synthetic Grade I material.

Chemical Processing of Metallic Ores

The development of the chemical method of ore refining has made possible the use of lateritic ores such as are to be used at Port Nickel. The only chemo-metallurgical process at present in use is that employed by Sherritt Gordon Mines Ltd. at Fort Saskatchewan, Alberta. This involves ammonia leaching of nickel sulphide concentrates containing an average of 35.6% iron, one of the principal reactions being :

$$FeS + 2\tfrac{1}{2}\,O_2 + 2NH_3 \longrightarrow \tfrac{1}{2}\,Fe_2O_3 + (NH_4)_2SO_4$$

In this process ammonium sulphate is formed when iron sulphide in the ore is converted to iron oxide during ammonia leaching. It also yields pure nickel metal but it is not based on reactions coresponding to those in the Chemico process employed at Port Nickel.

Ammonium Sulphate Sales

The ammonia to be used in the refining operations at Port Nickel will be purchased on the open market and no long-term arrangements for its supply have yet been made. The ammonium sulphate produced at the new plant will be offered for sale on the world market and it is likely that the bulk will be exported. It should have no difficulty in competing with synthetic or even by-product material as it is obtained most economically.

NITROGENOUS FERTILIZER FROM PEAT

The Shannonbridge Project

WIDESPREAD INTEREST is being shown in the projected Shannonbridge nitrogen fertilizer plant which will be the first in the world to use peat as the principal raw material. A committee appointed by the Eire Government, is at present studying all aspects of the project and will shortly submit a programme for Government action. Consideration is being given to a plant which will have an annual capacity of 100,000 tons of lime ammonium nitrate, 6,600 tons of nitric acid and 1,650 tons of anhydrous ammonia for industrial use.

The possibility of establishing a nitrogen fertilizer works in Eire was first considered 12 years ago and plans had almost been completed for a plant to manufacture ammonium sulphate from coal, but as ammonium nitrate is now considered to have a greater potential demand it will become the principal product of the new works. The whole project will involve a capital outlay of between £7 million and £8 million and the Government has approved in principle the provision of funds.

The new plant will be built some two miles south of Shannonbridge, Co. Offaly, between the main county road and the River Shannon and approximately a third of a mile from both the road and the river. The site, which appears to offer no special problems, will be about 50 acres to allow for possible future expansion. Cooling water may be drawn without charge from the river, the temperature of which ranges between 40°F and 60°F. As the Shannon is an important salmon fishery, the design of the plant will have to incorporate provision to prevent contamination of the river.

Limestone

Supplies of limestone will be available from Clorhane about two miles from the site, the analysis of this material being approximately:—

Calcium carbonate	92.8 - 94.0%
Magnesium carbonate	1.8 - 2.2%
Silica	2.7 - 3.3%
Aluminium and iron oxide	.9 - 1.1%

The limestone would be delivered to the works in rock form at 7s. 6d. per ton.

Peat

Milled peat will be delivered to the factory at 23s. 6d. per ton and would have the following characteristics :—

Moisture Content:
40-60%, average 50-55%

Sizing:
40% below 1/16"
60% below 1/8"
85% below 1/4"

Bulk Density:

Poor quality	9 - 13lb./cu. ft. @ 55% moisture content				
Fair quality	13 - 16	,,	,,	,,	,,
Good quality	16 - 20	,,	,,	,,	,,
Excellent quality	20 - 25	,,	,,	,,	,,
Average quality	19	,,	,,	,,	,,

The peat supplied will have a gross calorific value of 4,270 BTU and a net calorific value of 3,400 BTU at 55% content.

Analysis of Anhydrous Material

Carbon ...	57%	Indigenous ash	2.4%
Hydrogen ...	6%	Fixed carbon ...	30.6%
Oxygen ...	33%	Volatiles ...	67%
Nitrogen ...	1.3%		
Sulphur ...	.3%		
Indigenous ash	2.4%		

The peat ash will soften at between 1,000°C and 1,300°C, fuse at between 1,100°C and 1,400°C and flow at between 1,250°C and 1,450°C. Self oxidation will begin from between 150°C and 250°C but the volatiles immediately released will not ignite until a higher temperature is reached. This figure is not exactly known but is in the order of 500°C to 750°C. The ignition temperature and hence the risk of explosion from peat dust clouds of about 200 mesh size varies with the moisture approximately as follows :—

7% m.c. — 610°C
15% m.c. — 650°C
40% m.c. — 670°C

The flame temperature of the peat varies with the net calorific value and the quantity of excess air present. At 15% CO_2 the flame temperature is in the order of 1,100°C to 1,200°C within 3ft. of the fuel bed.

Peat Treatment Plant

The plant and equipment required for treating the peat will include bunkers, driers, hammer and ball mills, power units, conveyors, fibre separators and a gasification unit. Provision may also have to be made for a standby gasification unit and in view of possible variations in the composition of the milled peat the treatment plant will have a capacity about 40% in excess of that required for good quality material.

In view of the lack of experience in the use of peat as a raw material for hydrogen generation, it has been thought desirable that the gasification plant should be capable of operating on an alternative fuel such as anthracite duff, semi-bituminous coal or fuel oil. Anthracite duff would have an ash content of approximately 24.4% and a calorific value of 9,700 BTU, whereas Irish semi-bituminous coal would have an average ash content of 25% and 10,500 BTU.

Nitrogen Fertilizer Plant

In addition to the gasification plant, the works will comprise an oxygen plant, gas purification and conversion units, an ammonia synthesis unit, a nitric acid plant and installations for grinding and drying limestone, dust recirculation and the manufacture of the end product, lime ammonium nitrate.

Some factors of price and supply

Milled peat ...	23s. 6d. per ton. Adequate supplies for full requirements of the plant.
Limestone ...	7s. 6d. per ton.
Grade B fuel oil	c.£10 per ton at factory site.
Electricity ...	1.14d. per KWH at a voltage not lower than 3,000 volts.
Boiler water ...	3s. 6d. per 1,000 gallons.
Cooling water ...	Free from River Shannon.
Steam	5s. 0d. per 1,000 lbs.
Labour	3s. 0d. per hour.

Provision will also be made for the separate storage of ammonia and nitric acid for captive use and for sale.

Summary

The Shannonbridge nitrogen fertilizer project is still in the early stages of discussion and consultation, but the Eire Government's intention to see it materialise remains firm. Although the use of fuel oil is receiving attention as an alternative if peat proves to be inefficient, large-scale consumption of peat for nitrogen manufacture, despite the considerable technical problems in its use, would be very attractive from the point of view of Eire's economy. Despite the problems and difficulties which must be overcome, the project remains a sound proposition from the economic standpoint. Consumption of nitrogen in Eire is now at an annual level of 18,000 tons and the Government is anxious to see this figure trebled as soon as possible. Whereas the Shannonbridge project provides for the manufacture of lime ammonium nitrate, it may also prove expedient to divert some of the ammonia and nitric acid produced to the manufacture of complex fertilizers such as di-ammonium phosphate and nitro-phosphates. The output of the Shannonbridge plant together with that of the proposed ammonium sulphate plant at Cobh would make it possible to double the current rate of consumption. At present some £2½ million is spent each year on imports of nitrogen fertilizer and it is estimated that if completed by 1962 the Shannonbridge plant will repay its initial cost within six years.

UREA PLANT FOR INDONESIA

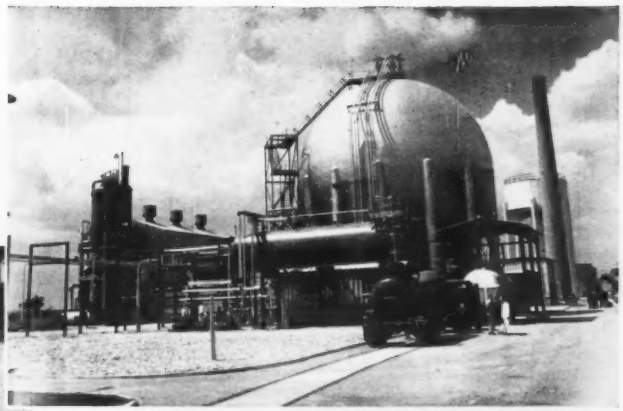
THE FIRST nitrogen fertilizer plant in Indonesia will be built for the Indonesian Government at Palembang in South-Eastern Sumatra. Due for completion in 1962, the new plant will have an annual capacity of 100,000 tons of fertilizer grade urea and its design will facilitate further expansion. Involving a capital outlay of $30 million, this project has been under consideration for several years but could not materialise for lack of funds. This obstacle was recently overcome when the Indonesian Government negotiated a loan from the U.S. Export-Import Bank.

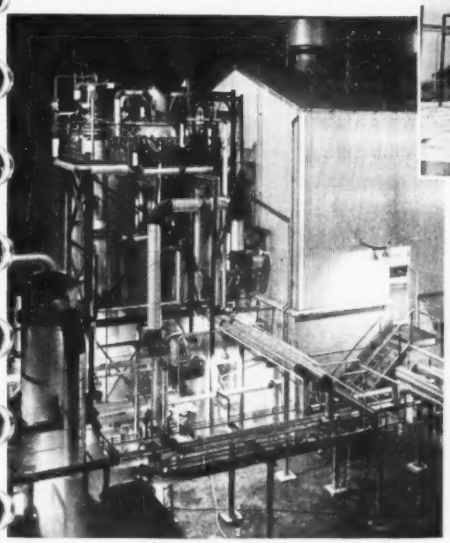
The new plant, to be built by Foster Wheeler Corporation of New York, will employ the Pechiney-Grace total recycle process. Ammonia synthesis will be carried out by the Casale process based on the use of natural gas which is to be supplied by the Standard Vacuum Oil Company from one of its fields in southern Sumatra by a 60-mile pipeline at a rate of 15 million cubic feet a day.

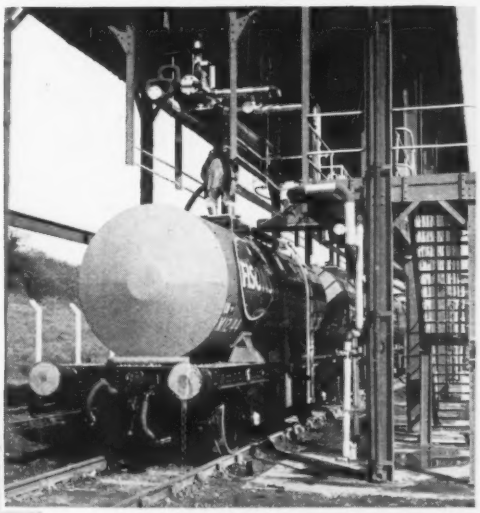
Consumption of nitrogen fertilizers in Indonesia is now at an annual level of 25,000 tons N, a figure which leaves room for a substantial increase in view of the density of population and intensity of cultivation in Java. The availability of domestic supplies is expected to stimulate demand and by reducing dependence on imports, to effect an appreciable saving in foreign exchange.

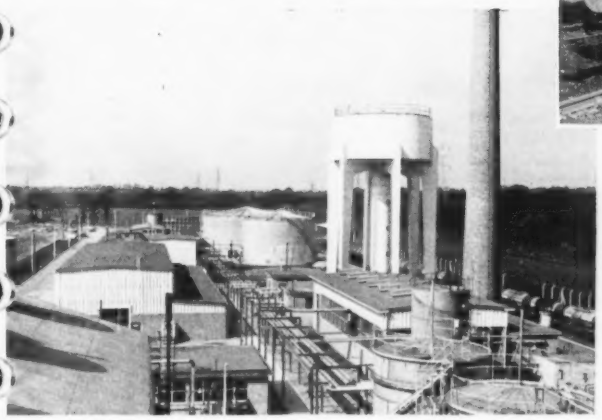
FISONS LTD.

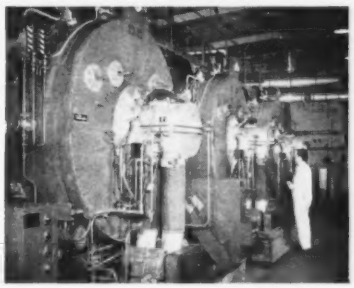
Ammonium nitrate and Nitric acid plant at STANFORD-LE-HOPE



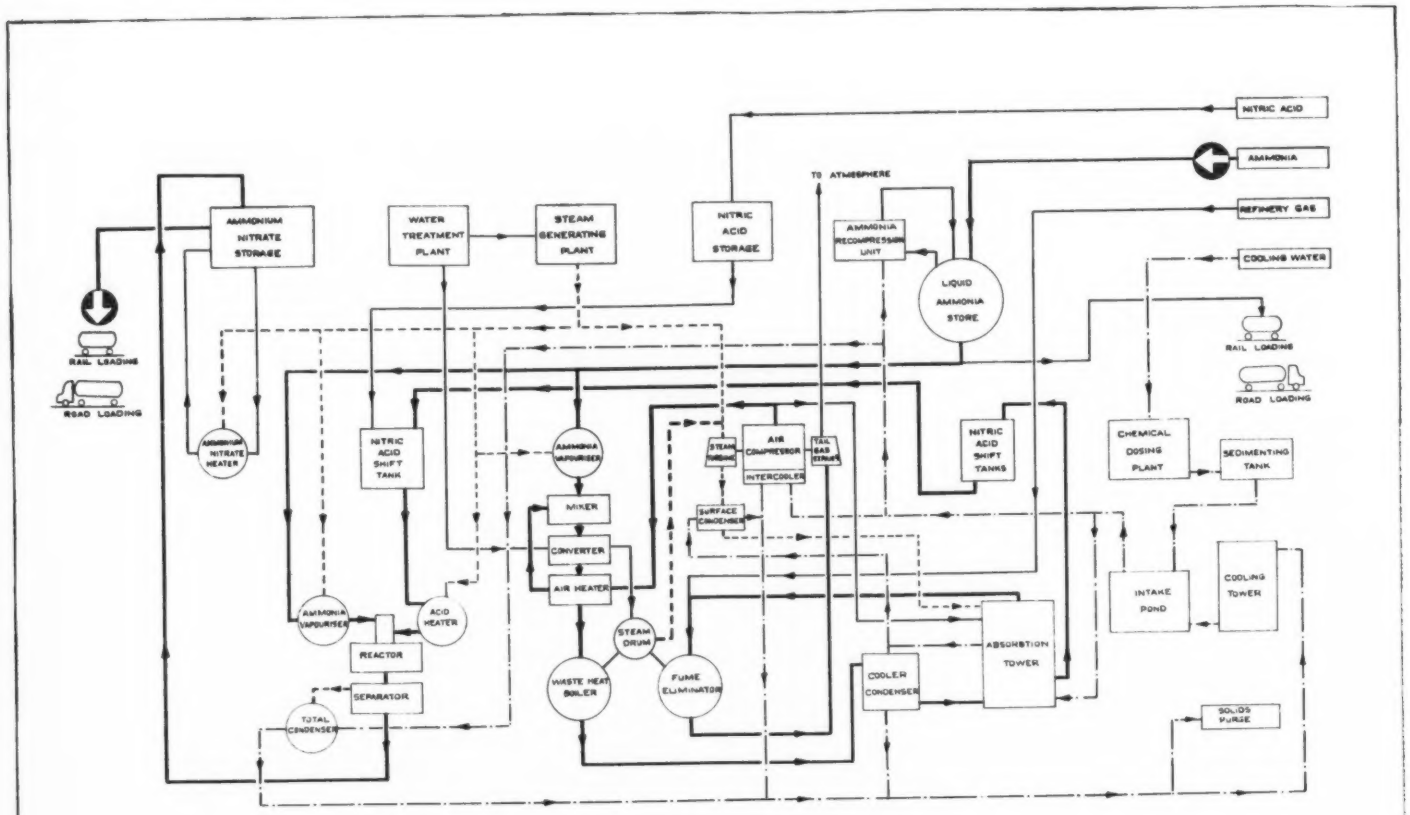








The nitric acid unit, employing a modification of the du Pont process, has a daily capacity of 223 tons (100% HNO_3) which is produced at a concentration of approximately 57.5% strength. The ammonim nitrate unit employs the Stengel continuous process with a minimum guaranteed ammonium nitrate yield of 98% and has a capacity of 400 tons a day. Both units were installed by Constructors John Brown Ltd. acting as associates of Chemical & Industrial International Ltd.



FISONS LIMITED — STANFORD LE HOPE FACTORY — PROCESS & SERVICES FLOW DIAGRAM.

The Ammonia Oxidation Process for Nitric Acid Manufacture

Early Developments with Platinum Catalysts

It is little more than 50 years since the first manufacture of nitric acid by the oxidation of ammonia over a platinum catalyst. Ostwald's original industrial plant had an output of some 100 tons of acid a year; to-day the world capacity for nitric acid manufacture by this process is about ten million tons a year. This article traces the beginnings and early developments of the process until it became commercially established.

DURING THE latter years of the nineteenth century discussion began to arise among men of science who were interested in the broader issues of their subject on what later became known as "The Nitrogen Problem." Typical of the expositions which now and then reached even the public press was the Presidential Address given by Sir William Crookes to the British Association for the Advancement of Science at its Bristol meeting in September 1898. Crookes was concerned to show that at the prevailing rate of increase of population the world's supplies of wheat would soon prove insufficient, and that the land would not continue to produce the same yield year after year unless adequate quantities of nitrogenous manure were ploughed back. He appealed to the chemist to help remove the fear of famine by establishing a means of fixing atmospheric nitrogen, since the only available source—Chile saltpetre — might be exhausted in a comparatively short period of years.

The Fixation of Nitrogen

This problem, of obtaining from the unlimited supplies of uncombined nitrogen in the atmosphere those compounds—principally ammonia and nitric acid—required for agricultural needs, was soon intensified by the realisation in a number of European countries that a precisely similar need for assured supplies of nitric acid existed in the manufacture of explosives, and that in the event of war the Chile nitrates might well prove to be inaccessible to one side or the other.

This is not to say that such thoughts inspired governmental action in any part of Europe; they were, in fact, confined to but a handful of scientists who could foresee their countries' long-term needs. One such man was Professor Pfeffer, the famous botanist, who in 1901 expressed his concern about the need for supplies of fixed nitrogen to his colleague in the University of Leipzig, Professor Wilhelm Ostwald. At this time Ostwald had occupied the Chair of Chemistry at Leipzig for some 14

Prof. Dr. Wilhelm Ostwald.

years and had built up a school of physical chemistry, devoting much of his energy to investigating the effects of catalysts on chemical reactions. His response to Pfeffer's representations was immediate; it was obviously his duty as a chemist to play his part in making his country independent of Chile saltpetre by obtaining nitric acid from other sources.

Two possible lines of investigation presented themselves. Either free nitrogen and oxygen from the air could be combined or ammonia,

then readily available from the gas industry, could be oxidised to give nitric acid. As it seemed more simple to re-combine nitrogen which was already fixed than to fix free nitrogen, Ostwald decided to give his attention to the oxidation of ammonia.

This reaction was not unknown, and in fact had been proved possible on a laboratory scale. As long ago as 1789 the Rev. Isaac Milner, F.R.S., President of Queen's College and first Jacksonian Professor of Natural Philosophy in the University of Cambridge, had presented a paper to the Royal Society entitled "On the Production of Nitrous Acid and Nitrous Air." In this Milner described a series of experiments in which he had passed "volatile alkali" (ammonia) over "calx of manganese" contained in a gun-barrel heated to redness. The product was found to be "highly nitrous," and the presence of "nitrous air' was confirmed by the appearance of red fumes on mixing with the atmosphere or with "dephlogisticated air." Milner continued: "I have since frequently repeated this experiment, and have always in some degree succeeded. Much depends on the kind of manganese employed, much on the heat of the furnace, and much on the patience of the operator; as these are varied, there will be great variations of the products . . . In general, I made use of clean gun-barrels with which no previous experiments had been made. The manganese was used in rough powder; for when it is too finely powdered, the tube is choaked and the air cannot pass."

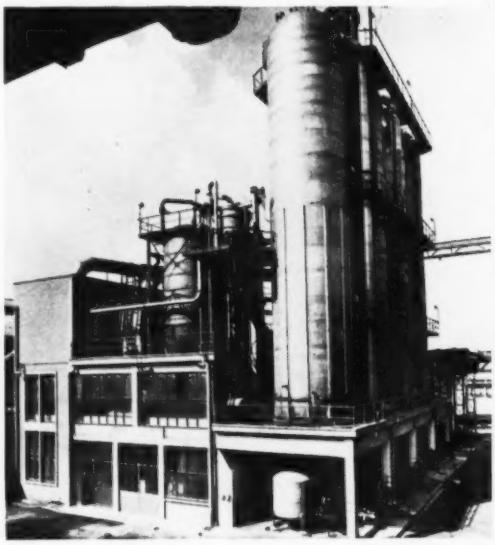
Kuhlmann and his Patent

More fundamental and extensive work had been carried out by Frederic Kuhlmann, the founder of the great chemical enterprise Etablissements Kuhlmann. Born at Colmar in 1803, Kuhlmann had been a student of Vauquelin and had been nominated by him to the newly-formed Chair of Industrial Chemistry at the University of Lille at the early age of 21.

He knew from the work of Lavoisier that ammonia was composed of nitrogen and hydrogen, and that nitric acid was composed of these two elements together with oxygen. He was also familiar with the early discoveries in catalysis made by Humphry and Edmund Davy and by Döbereiner, as well as with the work of Dulong and Thenard, reported in 1823, on the catalytic activity of the platinum metals in bringing about the combination of oxygen and hydrogen. He was particularly interested in the part played by nitrogen products in agriculture and in fact in later years carried out investigations on the use of ammonium salts as fertilizers on his own estate.

With this as his background, Kuhlmann went to work vigorously on the nitric acid problem, and found that by passing a mixture of ammonia and air over platinum sponge heated to about 300°C in a glass tube he obtained nitric acid. He filed a patent application for this invention in 1838.

At this time saltpetre was readily and cheaply available, and the new process could



Ets. Kuhlmann: Nitric acid plant at La Madeleine.

not offer any commercial advantage, but in the course of a paper given to the Société des Sciences de Lille in the same year, Kuhlmann made these prophetic remarks: "If in fact the transformation of ammonia to nitric acid in the presence of platinum and air is not economical, the time may come when this process will constitute a profitable industry, and it may be said with assurance that the facts presented here should serve to allay completely any fears felt by the government on the difficulty of

obtaining saltpetre in sufficient quantities in the event of war."

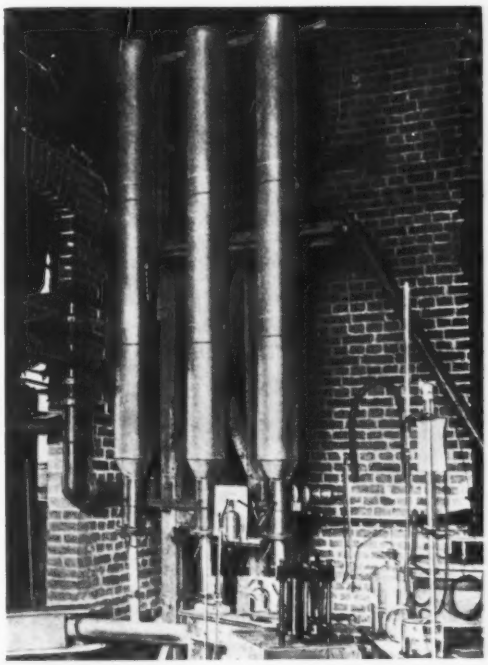
Today the great chemical firm that he founded is among the leaders in the large-scale production of nitric acid by the oxidation of ammonia over a platinum gauze catalyst.

Ostwald's Experimental Work

To return to Ostwald, it was clear to him that the theoretical basis of the ammonia oxidation reaction would have to be elucidated before it could be developed on a large scale, and experiments were begun by Dr. Eberhard Brauer, at that time Ostwald's private assistant. The first experiments were made using a clean glass tube only a few millimetres in diameter containing platinised asbestos. Ammonia and air were passed over the catalyst in known quantities and with known velocities and it was at once clear that the conversion to nitric acid was practicable and relatively simple to carry out, although some difficulties lay in the absorption of the reaction products.

The first experiments using platinised asbestos gave only small yields and a platinum-lined tube proved little better. A new reaction tube was therefore made, consisting of a glass tube 2 mm. in diameter in which was coiled a strip of platinum about 20cm. long. The whole tube was heated to redness, and the first experiment gave a conversion of more than 50%. Attempts to increase the yield by reducing the gas velocity or increasing the time of contact gave just the opposite result, while increasing the gas velocity gave a conversion of 85%. Ostwald, after several days brooding on this apparent anomaly, hit on the explanation; the nitrogen oxides formed could decompose to free nitrogen and oxygen if the time of contact between the gases and the catalyst were lengthened. Corroboration of this conclusion lay in the fact that unburnt ammonia was never detected behind the contact zone. This determined the course of further experiments, which included investigations on the effects of variations in the ammonia: air ratio, in the time of contact and in the temperature of the catalyst. Thus were laid the foundations of a technical process for producing nitric acid from ammonia, but the translation from idea to practice presented many problems before the project was brought to fruition.

A small factory was made available to Ostwald and Brauer, and here a pilot plant was developed. By 1904 the three converters illustrated below had been built and operated, and it was decided to erect a larger-scale plant at the Gewerkschaft des Steinkohlenbergwerks Lothringen at Gerthe, near Bochum, to produce 300 kgs. per day of nitric acid. This plant was brought into operation in May 1906 and fully proved the feasibility of the process. A larger-scale plant was then designed and built,



The three reactors of the pilot plant built by Ostwald and Brauer in 1904.

and by the end of 1908 was producing some three tons of 53% nitric acid per day.

The catalyst used at this time consisted of a roll of corrugated platinum strip about 2cm. wide and weighing about 50g., heated initially by a hydrogen flame. The life of the catalyst was no more than a month or six weeks. The disadvantages of the process included the relatively large amount of platinum required per unit of acid produced, and the uncertainty of temperature control of the catalyst, but improvements were not long wanting.

The Platinum Gauze Catalyst

Dr. Karl Kaiser, of the Technische Hochschule, Charlottenburg, attacked the problem, and filed patents in 1909 covering the preheating of the air to 300° or 400°C and the use of layers, usually four in number, of platinum gauzes. He was the first to employ platinum in the form of gauze, and it is a tribute to his experimental skill that the precise form of gauze he settled on—wire 0.06 millimetre diameter woven to 1,050 mesh per square centimetre—is still very largely employed. By 1912 Kaiser had a pilot plant in operation at Spandau, Berlin, but while this was inspected repeatedly by British, French and American industrialists, he failed to interest them in his process, although a plant was erected at Kharkov in Russia.

A little earlier, in 1907, Dr. Nikodem Caro, of the Bayerische Stickstoffwerke A.G., and Adolph Frank, the joint inventors of the Cyanamide process, had claimed a method of producing nitric acid from ammonia by means of a catalyst consisting essentially of thorium oxide admixed with small amounts of rare earths such as cerium oxide. This process failed, chiefly because the catalyst sintered and rapidly became impermeable, but further work was carried out by Caro and Frank's son Albert, who was then a chemical engineer at the Bayerische Stickstoffwerke. Several patents were filed during 1914, the process being based upon a single platinum gauze which was electrically heated. Progress was slow for a time, and numerous experimental plants failed, but the outbreak of war gave a much greater urge to the project and by 1916 the picture had changed radically. The Frank and Caro converter had by then been engineered by the Berlin - Anhaltische Maschinenbau A.G. (BAMAG), who had constructed more than 30 plants, first for the supply of nitric oxide to lead chamber sulphuric acid plants and later for nitric acid production. The single platinum gauze was subsequently replaced by multiple gauzes, and the electrical heating was discontinued. This type of plant supplied all the nitric acid required for explosives in Germany during the latter years of the war. The converter had a diameter of 20 inches, the catalyst consisting of a layer of three platinum gauzes woven from 0.006 inch diameter wire of 80 mesh to the linear inch, operating at about 700°C. The three gauzes were spot welded to a platinum grid and retained in place by embedding in asbestos. A much greater catalyst life was obtained in this design of plant, extending to six months provided that conditions were uniform and that the gases were free from impurities that might have a poisoning effect.

Initial Production in America

At the beginning of the 1914-18 war the United States possessed no source of nitric acid other than Chile saltpetre, and it became distressingly evident that the nation was dependent upon a foreign country in this respect, while the production of nitric acid from this starting point required large quantities of sulphuric acid already in short supply.

Cyanamide had been manufactured at Niagara Falls since 1909, and in 1916 the first American plant for the oxidation of ammonia produced from cyanamide was established by the American Cyanamid Company at Warners, N.J. The catalyst employed was a single platinum gauze, electrically heated. In the meantime, the Ordnance Department had decided to take action, and Dr. C. L. Parsons, of the Bureau of Mines, was asked to investigate European methods for nitrogen fixation. As a result the American Cyanamid Company was requested, in 1917, to form a subsidiary company, Air Nitrates Corporation, to act as agent for the United States Government for the construction and operation of a plant at Muscle Shoals, Alabama, to produce 110,000 tons a year of ammonium nitrate. This plant comprised some 700 catalyst units each containing a single rectangular platinum gauze woven from 0.003 inch diameter wire, 80 mesh, and heated electrically to 750°C. The total weight of platinum was a little over 300oz., and the loading ratio about 1kg. per daily ton of ammonia.

A smaller plant was also erected by the government at Sheffield, Alabama, and here a different approach was adopted to the catalyst design, aimed at conserving a greater proportion of the heat of reaction. Four layers of 80 mesh platinum gauze were rolled into a cylinder, which was heated by torch for a short time; on passing the ammonia-air mixture the

reaction started at once and then became self-sustaining for many months. This construction was later abandoned, however, on account of the difficulties in installing and operating the gauze cylinder.

Developments in Great Britain

There had been little or no commercial interest in nitrogen fixation in Great Britain before the outbreak of war in 1914, and throughout the war period the supply of nitrogen products for munitions depended almost entirely on Chilean nitrate. Towards the end of the war, ammonium nitrate for the manufacture of Amatol was being prepared at the rate of one million tons a year by the double decomposition of sodium nitrate and ammonium sulphate, a process based on F. A. Freeth's studies of the phase rule.

There were, however, a number of attempts to make nitric acid by the direct oxidation of ammonia, either from gas-liquor or cyanamide. An Ostwald plant was set up at Dagenham Dock by the Nitrogen Products Company in 1916-17, but never achieved successful operation. The Gas Light and Coke Company developed a plant at Beckton using a pad of three or four flat platinum gauzes as catalyst, and attained an output of one ton of nitric acid per day.

A systematic investigation was undertaken at the instigation of the Nitrogen Products Committee, by Professor J. R. Partington and Dr. L. H. Parker, and was carried out in the laboratory of the Munitions Inventions Department. An effective design of converter was evolved, employing either an electrically heated pad with two gauzes or a thicker pad that was self-sustaining in temperature when reaction had been established. Somewhat similar converters were constructed by Brunner Mond and Company and by the United Alkali Company, the latter of a pattern that is still in widespread use in the sulphuric acid chamber plants, constructed of enamelled cast iron with an integral tubular heat exchanger.

Although it came too late to be of service in the war, the decision taken in 1917 to erect a synthetic ammonia plant using the Haber-Bosch process led directly to the building of the Billingham plant by Synthetic Ammonia and Nitrates Ltd. (now Imperial Chemical Industries Ltd.). The ammonia plant first came into operation in December 1923 and the nitric plant—the first successful large-scale plant in this country—during 1927.

Although the process remains unchanged in principle—even in some details such as the mesh sizes of the gauze pads—the size and complexity of the plant units has been tremendously increased. The first commercial operation at Lothringen Colliery produced 300 kgs. per day of weak acid. The most recently erected single units, working at a pressure of 120lb. per sq. in. have an output of 250 tons per day (100% HNO_3). From the 50 grammes of corrugated foil in an Ostwald unit, the weight of platinum in a single converter has steadily increased until it may now be 15 kgs. or more, but the ratio of platinum installed per daily ton of ammonia burned has fallen from over one kilogramme to 250 grammes or less.

We are indebted to Mr. L. B. Hunt, M.Sc., Ph.D., of Johnson, Mathey & Co. Ltd., for placing this article and illustrations at our disposal.

PRE-NEUTRALIZATION

Spencer Chemical's Pilot Plant Tests

AN IMPORTANT MILESTONE in the progress of the technique of mixed fertilizer manufacture was the development in 1957, by the Virginia-Carolina Chemical Corporation, of a "pre-neutralizer" in which the free ammonia in nitrogen solutions was reacted with sulphuric acid, adding the resulting ammonium sulphate and ammonium nitrate solution to an ammoniator where it mixed with potash, dolomite, solid ammonium sulphate and recycled to form X-O-X grades.

Although the use of a pre-neutralizer holds an important potential for obtaining large quantities of nitrogen from low cost solutions, its use presented a number of formidable technical problems to prospective operators. Recognising the need for first-hand information in order to offer dependable technical assist-

ance to customers, the Spencer Chemical Company of Kansas City, Missouri commissioned its Pilot Plant Group to make an extensive investigation of this important development. The Company has issued a full report on the techniques developed in this pilot plant study which show that in commercial scale operations it is possible to obtain all the nitrogen in X-O-X grades from solutions, make inverted ratios like 20-10-10 and 16-8-8, and to reduce greatly the recycle required in 1-1-1 ratios when all the nitrogen is derived from solutions.

Pilot Plant Operation

A complete granulation plant with a capacity of 250 lbs. per hour was installed containing a stainless steel pre-neutralizer tank 18" in diameter, 4' high with an overflow 11" from the bottom. Water was mixed with 66° Bé sulphuric acid and then cooled in a water-jacketed coil before entering the pre-neutralizer. Potash and filler were weighed, mixed and fed from the hopper by an Omega feeder.

The first attempt at granulation resulted in a wet material in the ammoniator section. It was decided that the material was being retained in the ammoniating section for too long, so the dam between the ammoniating and granulating sections was removed. The product although fairly dry, tended to granulate in large balls, the recycle rate varying from 250 to 500 lbs.

A T.V.A. type reciprocating slurry distributor with an 18" stroke was installed but granulation was not improved by this device and trouble in line freeze-up was encountered. The distributor was removed and the dam replaced. At this stage of the project the operating temperature of the pre-neutralizer was held at a maximum of 245°F. Attempts to increase this by reducing the water input resulted in excessive fuming and apparent decomposition of the material. It was subsequently discovered, however, that the fuming was caused not by the temperature but by the acidity of the material.

An air jet was tried as a means of cooling and distributing the overflow from the pre-neutralizer over the ammoniator bed, but this was not found to be practical since large quantities of air were required. A filler that was more resistant to granulation, composed of 20% diatomaceous earth and 80% dolomite, was also tried. This gave a drier mix in the granulator, but was not practical from the cost standpoint and was found to be unnecessary by later experimentation.

It was found that if the acidity was kept at 2% as H_2SO_4 or below, the temperature could be taken to 300°F without excessive fuming. At this temperature the granulation became dry even with 0.5 to 1 recycle rate. The temperature of the pre-neutralizer as well as the granulation can be controlled by the addition of more or less water to the pre-neutralizer.

Control of Acidity of the Pre-neutralizer

The tests established that for a number of reasons the acidity of the pre-neutralizer should be carefully controlled. If the acidity becomes too high, nitrogen can be lost as nitric acid. Sulphuric acid can replace nitric acid in a salt resulting in boiling off nitric acid at the operating temperature.

$$2NH_4NO_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + 2HNO_3 \uparrow$$

If the pre-neutralizer becomes too alkaline, there will be a loss of nitrogen by flashing of ammonia, which can be easily detected by smell. An increase in acidity in the pre-neutralizer results in an increase of ammonium bisulphite, which being much more soluble than the neutral sulphate, readily picks up water. This results in a product that collects moisture from the air and any small spills will soon appear as pools of liquid in damp weather. If the pre-neutralizer is run close to the neutral point, the product will be much less hygroscopic.

When run on the acid side, the pre-neutralizer gives off much greater quantities of fumes. It was originally believed that 245°F was the maximum temperature that could be reached without excessive decomposition, but with controlled acidity this can be increased to 328°F.

When operating on the acid side the material leaving it becomes green in colour, particularly when in contact with mild steel. This is caused by the presence of metallic salts, principally iron. When the solution is increased

to lower the pH to nearly neutral, the colour changes to brown, caused by iron changing from iron sulphate or nitrate to oxide or hydroxide. The brown colour will diminish with continued operation showing that less corrosive attack takes place when acidity is reduced.

Whenever ammonium bisulphate is formed by over acidity and dolomite is used as a filler, the bisulphate reacts slowly with the dolomite to give ammonium sulphate, calcium sulphate, magnesium sulphate, carbon dioxide and water. If this reaction were to take place in a pile or bag, it would cause caking, especially if a large quantity of ammonium bisulphite were present and, with the use of an unreactive filler such as sand, the acidity of the bisulphate would cause bag rot.

Filling Material

Dolomite, probably the best filler for X-O-X grades, in addition to adding magnesium to the fertilizer, acts as an anti-acid without liberating excess ammonia. Sand can also be used as a filler but the product is less attractive. Agricultural limestone was used in place of dolomite in a demonstration run, but it gave a noticeable liberation of ammonia over a long period and cannot be recommended as a filler.

X-O-X grades have a high tendency to cake but it was found that this was considerably reduced by the use of a 1% parting agent. There is not yet, however, enough experience on the use of anti-caking agents to form a basis for specific recommendations.

Safety Precautions

Several safety precautions must be observed in the manufacture of X-O-X grades. The product should always be dried at a low temperature. The burner throat temperature should not exceed 400°F and direct contact with the flame should never be allowed. Decomposition will start at about 450°F and will accelerate as the temperature rises, giving off a dense white irritating fume. A drier, full of decomposing X-O-X would be dangerous to an entire plant, and as soon as the dry feed is stopped at the granulator, the furnace should be immediately shut off, thereby preventing over-heating in an underloaded drier.

Organic fillers or parting agents such as wood, flour and ground corn cobs should never be used on X-O-X grades. Tests made on sawdust mixed with 14-0-14 were very convincing, the mixture burning rapidly when only a small corner of the container was heated in a flame. Flamable materials such as piles of old paper bags should also be kept away from X-O-X grades.

The molten salts in the pre-neutralizer are always a potential safety hazard and should be watched, especially during start-up operations. A blockage in the overflow line causing an overflow of molten material at 275°F to 325°F would be extremely hazardous.

Conclusions

In the course of several months experimentation on the manufacture of 14-0-14, the Technical Department of the Spencer Chemical Co. drew a number of important conclusions. Satisfactory plant operation can be maintained at a recycle rate of 0.5 to 1 or even less using a 19-74-0 solution and 66° Bé sulphuric acid. Careful control of acidity of the pre-neutralizer is essential to maintain even operation, to obtain a less hygroscopic product, to prevent loss of nitrogen and to reduce corrosion of equipment.

The addition of water to the pre-neutralizer through the solution sparger was found to be a satisfactory method of controlling temperature in the pre-neutralizer and in granulating operations, where a temperature of between 275°F and 300°F gave good granulation at a recycle rate of 0.5 to 1.

Drying the product at a low temperature was found to be helpful in preventing caking and attaining a more attractive product, but this does not preclude the possible use of a parting agent.

IMPROVED AMMONIUM SULPHATE CRYSTALLIZATION

by Oesterreichische Stickstoffwerke A. G.

SOLID, crystalline ammonium sulphate is recovered from substantially neutral aqueous solutions of ammonium sulphate on a commercial scale almost exclusively by concentration in evaporators. Oesterreichische Stickstoffwerke A.G. of Linz, Austria, are patenting a process whereby the pseudo-hexagonal prisms of ammonium sulphate of the "grain of rice" type which had previously been produced only in an acid medium by the so-called saturator process, can be recovered from an alkaline solution. The " grain of rice " type crystals of ammonium sulphate are popular with consumers because they remain free-flowing even after prolonged storage and are suitable for use in fertilizer broadcasting machines.

Saturation and Crystallization

The first step in the new process involves saturating a solution of ammonium sulphate with gaseous carbon dioxide and ammonia in stoichiometric proportions of ammonium carbonate, at such a temperature that no precipitation of ammonium sulphate takes place, and thereafter cooling the solution to a temperature not below that at which ammonium carbonate begins to crystallize. The precipitated crystalline ammonium sulphate is then separated from the mother liquor.

The ammonia and carbon dioxide are fed into the absorption tower at a ratio of 5.65 kilogrammes of ammonia and 7.35 kilogrammes of carbon dioxide to 100 kilogrammes of ammonium sulphate solution with an ammonium sulphate content of 42% by weight. The feed continues until the vapour pressure is equal to the applied gas pressure. At atmospheric pressure this occurs when the temperature, which has been allowed to rise gradually, reaches about 60°C. The supply of carbon dioxide and ammonia is then stopped and the solution is transferred into a crystallizer in which the mother liquor can be circulated by a pump during crystallization and which has a funnel-shaped bottom enabling the largest crystals to be discharged. As the solution is cooled to 20°C, ammonium sulphate crystals are obtained in a shortened "grain of rice" form with a size of 2-3 m.m. or more. Eight kgs. of crystals are obtained from 14.8 kgs. of ammonium sulphate solution.

It is, of course, possible for saturation and crystallization to be carried out in the same vessel, but it is preferable to use a separate crystallizer of the type which effects separation at the same time as this promotes the formation of large and uniform crystals. In this controlled method of crystallization there is only a slight co-precipitation of ammonium carbonate and the product can be recovered as practically pure ammonium sulphate by centrifuging and a single washing step.

The crude crystals, containing less than 1% ammonium carbonate, are washed by being covered once with pure ammonium sulphate and are then centrifuged.

Recycle

As only a small part of the ammonium sulphate is recovered from the mother liquor after a single saturation and crystallization, a recycle system is commercially desirable.

In one system the process of saturation and crystallization may be repeated until ammonium carbonate (or carbaminate) precipitates immediately upon cooling. For each kilogramme of mother liquor returned to the absorption tower, 68 grammes of ammonia and 88 grammes of carbon dioxide are introduced, the temperature being again raised to 60°C. Slow cooling to 20°C in the crystallizer as before will give an additional 94 grammes of coarsely crystalline ammonium sulphate in a shortened "grain of rice" form.

On being returned to the absorption tower the mother liquor from this second crystallization is absorbed with 39.5 kilogrammes of ammonia and 51.5 kilogrammes of carbon dioxide at a temperature rising to 50°C. On cooling to 20°C in the crystallizer, every 100 kilogrammes of mother liquor yields 54 kilogrammes of coarsely crystalline ammonium sulphate. The mother liquor from this third crystallization may be diluted with water and reacted with gypsum to produce more ammonium sulphate.

Recycling may be carried out in an alternative system which involves only one saturation step and one crystallization step. 150 kilogrammes of mother liquor from the first crystallization are added to 100 kilogrammes of ammonium sulphate solution having an ammonia content of 42% by weight. 16.4 kgs. of ammonia and 21.3 kgs. of carbon dioxide are introduced in stoichiometric proportions into this solution while the temperature in the absorption tower is allowed to rise to 60°C. Cooling to 20°C in the crystallizer yields 22.8 kgs. of ammonium sulphate crystals of the "grain of rice" type for every 250 kgs. of mother liquor.

Reaction with Ammonium Sulphate

The ammonium carbonate solution obtained after separation of the precipitated crystalline ammonium sulphate may be reacted with calcium sulphate to form ammonium sulphate and calcium carbonate. The ammonium sulphate solution obtained after separation of the calcium carbonate may then be again saturated with carbon dioxide and ammonia, thus closing the cycle.

Conclusions

An important advantage of the new process is that it can be readily incorporated into the manufacture of ammonium sulphate from calcium sulphate by the direct reaction of ammonia and carbon dioxide and that the recovery of crystalline ammonium sulphate requires the evaporation of only the amount of water which may be added during the process as water of hydration of calcium sulphate and for washing the calcium carbonate. This eliminates the considerable amount of water evaporation normally required in ammonium sulphate manufacture by sulphuric acid thereby effecting considerable economy of operation, while at the same time yielding a final product of similar quality to that obtained with established processes.

It is advantageous and convenient to combine the new precipitation process with a normal evaporation-crystallization process so as to obtain substantially equal quantities of solid ammonium sulphate by both methods. In such a combined process 45-48% less water need be evaporated than in a pure evaporation process.

Another advantage of the new precipitation process is that it yields crystals of larger grain size than the evaporation process and that when washed with a slightly ammoniacal solution of ammonium sulphate, these crystals are more durable in storage and show a reduced tendency to cake and harden.

Now that the competitive pressure of other nitrogenous fertilizers in terms of nutrient content and price are becoming increasingly attractive, manufacturers of ammonium sulphate are closely watching any developments which could make their product more competitive. Particularly in cases where gypsum is used, the new precipitation process is likely to commend itself as a method for obtaining high quality ammonium sulphate crystals at the lowest possible cost.

SAFETY OF UREA-AMMONIA SOLUTION IN PRE-NEUTRALIZATION

CONSIDERABLE ATTENTION has recently been focused in the United States on the danger of toxic gases being evolved when ammoniating solutions containing urea are mixed with sulphuric acid in the pre-neutralization step of certain fertilizer granulation processes. E.I. du Pont de Nemours Inc. of Wilmington, Delaware, in an extensive programme of research, have established that undesirable conditions are caused only when the ammoniating solution contains ammonium nitrate in addition to urea.

In tests carried out in a laboratory "pre-neutralizer" unit, the gases given off were collected, and analysed by mass spectrographic and infra-red techniques. Based on the complete materials balance of each test the final contents of the pre-neutralizer were identified. The ammoniating solution was introduced into well agitated 95% sulphuric acid, the mixture being maintained at a temperature of between

200° and 260°F and gas samples were taken near the beginning and end of each run.

Urea-Ammonia Solutions

The "Uramon" ammonia liquor UAL-B used in these experiments has the following composition:—

Ammonia	30.5%
Urea	43.3%
Water	10.0%
Carbon dioxide	10.0%

In each run approximately 150 parts of UAL-B were added to 300 parts of 95% sulphuric acid during a one-hour period at an average temperature of 240°F. Analysis of the partly neutralized acid by the urease enzyme method showed that 92% of the urea added remained unchanged and that no loss of nitrogen occurred. The small amount of ammonia formed by urea hydrolysis was absorbed by the acid and all the nitrogen added was formed in the liquor.

The gas given off contained 99.9% carbon dioxide and its weight was almost exactly equal to the carbon dioxide initially contained in the "Uramon" ammonia liquor plus that formed by the hydrolysis of 8% urea. No indications were found in the evolved gas of any decomposition products other than carbon dioxide. Duplicate arrangements with urea-ammonia compositions containing no carbon dioxide gave the same results in that no gaseous products were found other than carbon dioxide which was evolved in amounts corresponding to the equivalent urea hydrolysis of less than 10%. Less than 1% biuret was found in any of the partially neutralized liquors.

Ammonium Nitrate-Urea Solutions

A solution composed of 20% ammonia, 68% ammonium nitrate, 6% urea and 6% water was introduced into 95% sulphuric acid in a ratio of 1:2 as with the "Uramon" solutions in the previous tests. Practically no urea was found in the resulting partially neutralized acid and 5% of the total nitrogen introduced into the system was lost.

During mixing copious quantities of gas were evolved. Mass spectrographic and infra-red analysis of six gas-stream samples from the pre-neutralizer showed the following range of compositions:—

Nitrous Oxide	47.2 to 52.4%
Carbon dioxide	45.0 to 52.2%
Nitrogen dioxide	0.6 to 3.5%
Nitrogen	0.5 to 3.6%
Water vapour	0.2 to 1.2%

The amount of carbon dioxide was in each case that which would be evolved by hydrolysis of the urea, while the amount of nitrogen lost from the system corresponded to the nitrous oxide formed.

This effect of ammonium nitrate on urea decomposition in the presence of strong sulphuric acid and the generation of nitrous oxide and carbon dioxide as major by-products can be explained by several hypothetical reactions. Most of these lead through the intermediate stages of urea nitrate and nitro-urea formation with ultimate decomposition of the latter to equivalent quantities of carbon dioxide, nitrous oxide and ammonia.

Ammonium Nitrate-Ammonia Solutions

To determine the source of nitrous oxide, experiments were made with a solution consisting of 22% ammonia, 65% ammonium nitrate and 13% water. Analysis of the pre-neutralizer liquor showed very little loss of nitrogen during mixing. Although nitrogen oxides were identified by the brownish fumes in the pre-neutralizer they were not present in sufficient volume to pass into the scrubber and trap system. Analysis of the gas from the top of the pre-neutralizer showed it to be a mixture of several nitrogen oxides.

Conclusions

Several important facts have been established by the series of tests. Urea solutions containing no ammonium nitrate give off only harmless carbon dioxide when added to strong sulphuric acid and relatively insignificant hydrolysis of the urea occurs even over periods of up to one hour at temperatures of 220° to 250°F in the neutralizing vessel.

When ammonium nitrate is added to urea solutions, a different set of chemical reactions occurs. Mixing an ammonium nitrate-urea solution with sulphuric acid generates copious and nearly equal amounts of nitrous oxide and carbon dioxide together with small quantities of nitrogen dioxide. In addition, the presence of ammonium nitrate greatly aggravates urea breakdown to the extent that the urea is almost completely destroyed under the conditions of pre-neutralization employed. On the other hand, ammonium nitrate solutions containing no urea give off only small quantities of mixed nitrogen oxides during pre-neutralization.

PUMPING HOT CONCENTRATED SOLUTIONS OF AMMONIUM NITRATE

THE RUSSIAN NITROGEN INDUSTRY is showing considerable interest in the development of improved methods of granulating ammonium nitrate and, in particular, in the system whereby ammonium nitrate solution is pumped to the top of the granulating tower having been concentrated by evaporation under vacuum on a lower level. This method affords savings in construction and operating costs, as the wall thickness of the granulating tower can be substantially reduced and the acid-resistant brick can be replaced by rubberized sheet or aluminium foil.

One of the principal problems is pumping the hot concentrated solution of ammonium nitrate with its rapid rate of crystallization and the risk of explosion occasioned by friction; this necessitates the use of explosion-proof pumps.

Centrifugal Pumps

In normal centrifugal pumps the compression elements are in direct contact with the material to be pumped and at high revolution rates local heating of ammonium nitrate would result in crystallization and decomposition. Centrifugal pumps with oil compression can be ruled out as the ammonium nitrate would become contaminated by oil and decompose. Satisfactory results have, however, been obtained with packing glands made of degreased asbestos cord wrapped in aluminium foil. While in operation this gland is kept wet with water and the pump itself is steam-jacketed to prevent crystallization. Centrifugal pumps with spring-loaded packing glands are also receiving attention from the Russian and East German Nitrogen Industries and are actually in use in East Germany at Leuna-Werke.

The "Mor" Pump

Two types of pump for handling ammonium nitrate have been recently tried out at the Stalingorsk Chemical Combine and The Kemerovsk Nitrogen Fertilizer Works using ammonium nitrate of 93.0 - 95.0% and 97.5 - 98.5% respectively.

The pump tested at the Stalingorsk Chemical Combine was of the "Mor" type with the following characteristics:

Diameter of intake tube ...	1.6"
Capacity	250 litres per min.
Height raised	108' 6"
Engine speed	2,900 r.p.m.

The ammonium nitrate was pumped up to 62' 4" from a reservoir to which it was returned. The delivery and offtake pipes had a diameter of 2.1" and were made of titanium-stabilized 18/1 nickel-chromium steel with a steam-jacket and thermal insulation. Steam at a pressure of 63.21-70.56 lbs. per sq. inch was used for heating. A manometer which had been calibrated with compressed air was used to measure the pressure of the ammonium nitrate in the pressure line, the top of which was equipped with an air trap to prevent the formation of air locks.

For the first ten days the pump was used on ammonium nitrate of 93.0 - 95.0% concentration and for the next five days on material of higher concentration when the following conditions were obtained:

Concentration of ammonium nitrate	97.5 - 98.4%
Temperature in the reservoir ...	135 - 138°C
Temperature in the supply line ...	146 - 150°C
Temperature of the heating steam	150 - 152°C
Pressure of heating steam in supply jacket	66.2 - 73.5 lbs.p.s.i.
Height raised	62' 4"

The only abnormal result of these tests was that the solution became diluted with steam.

A similar pump was tested at the Kemerovsk Nitrogen Fertilizer Works for 18 days. Its characteristics were as follows:

Diameter of intake tube	2"
Capacity	1,000 litres per min.
Height raised	164'
Engine speed	2,900 r.p.m.

The ammonium nitrate was circulated from vacuum evaporators to the buffer tank of the granulating tower, which was not working and from there to the ammonium nitrate tank on the first floor. From the latter it was raised to the level of the buffer tank 121 feet above the level of the pump.

The intake line, made of stainless steel, was 121 feet long vertically and 131 feet long horizontally, had a diameter of 2.9 inches and had eight right-angle bends and two obtuse angle bends. Both the intake and offtake lines were provided with steam-jackets and insulated with asbestos cement.

Measurements were taken every two hours during the test, the pressure of the solution in the offtake line being measured with compressed air as in the Stalingorsk tests, whilst pumping efficiency was measured by the changes in the level in the buffer tank.

The pump was used for 15 days on ammonium nitrate of 93 - 95% concentration which was then gradually increased to 98 - 99%. This concentration was maintained for three days. The averaged results of this test were as follows:

	Solution temperature at tank exit	*at tower exit*	*Concentration of ammonium nitrate*	*Pressure in off-take line (p.s.i.)*	*Loss of intake pressure (p.s.i.)*	*Pump efficiency cu. metres/hr.*
Circulation only ...	154.6°C	151.8°C	97.5%	85.3	8.4	9.0 - 9.5
To granulation tower ...	151.0°C	—	98.5%	88.2	11.1	15.3 - 15.9
Maximum throughput ...	—	—	98.5%	91.1		16.6

During the test the pump had to be stopped only once when strong smoking occurred from the shaft of the pump. This was because the seal of the hood was loose and oil had fallen from the case of the centrifugal governor into the solution. When this defect had been rectified the pump again worked normally. Crystallization occurred at some points in the piping, making pumping difficult, and before each run both the pump and the lines were cleared with steam.

The "KLNZ - 6/30" Centrifugal Pump

Similar tests have recently been carried out at the Kemerovsk Works with the KLNZ - 6/30 type of centrifugal pump. Made of chromium steel with a modified packing gland, this pump has a capacity of 30 cu. metres per hour at a maximum lift of 24.5 metres.

To ensure that ammonium nitrate did not fall into the compression chamber, condensate or steam was fed into the housing of this unit at 9 atm., thus creating a higher pressure than that of the solution on the compression assembly. By feeding steam at 9 atm. at the rate of 8 - 10 kg. per hour to the packing gland, the solution became diluted but the effect did not exceed 0.1% NH_4NO_3.

As it was shown that the pump had no difficulty in raising a 98 - 98.5% solution by 37 - 41 metres, it is understood that the next test will be to raise the solution 45 metres at a rate of 20 to 25 cubic metres an hour.

Conclusion

The trials established that centrifugal pumps built of corrosion-resistant material and fitted with special compression units can be recommended for handling hot concentrated solutions of ammonium nitrate. At the same time certain essential operating conditions must be observed. Pumps should be started up on a 95% solution with circulation for a certain period, and then be switched over to a 98.5% solution to the granulating tower. The pumps must be protected against crystallization by insulating the pipelines, by providing for adequate injection of steam or water and by steam-jacketing. Separate pipelines should be provided for each pump and it is essential for the safety valve on the emergency tank to be fitted in duplicate. All lines should be steamed through before starting up.

It is understood that all ammonium nitrate granulation units now under construction in the Soviet Union will be equipped with centrifugal pumps of the type tested at Stalingorsk and Kemerovsk. Interest is now, however, beginning to turn to a glandless, immersion-type pump which would afford a considerable reduction in the length of piping required, and tests are expected to start before long.

casebook

THE TREATMENT FOR LOW CARBON STEELS

Problem

IN ORDER TO reduce the overall size and to increase the efficiency of electrical transformers, low carbon grain-oriented silicon steels have been developed. These steels are used to make the laminations which form the core of the transformers. The carbon content of the steel is kept as low as possible—0.008% being common. For this reason the steel is highly susceptible to carbon pick-up when heated. Any heating operation must therefore be carried out under a controlled atmosphere, which must of course be non-carburizing.

After cold rolling and shearing to size, the laminations are punched. These operations must be followed by stress-relieving, a process which is conventionally carried out in lift-off furnaces using a batch process. To heat and soak a load of laminations in this kind of furnace requires a 45 to 50 hour heating cycle, during all of which the laminations must be surrounded by a non-carburizing gas, since even slight traces of carbon would be absorbed by the steel.

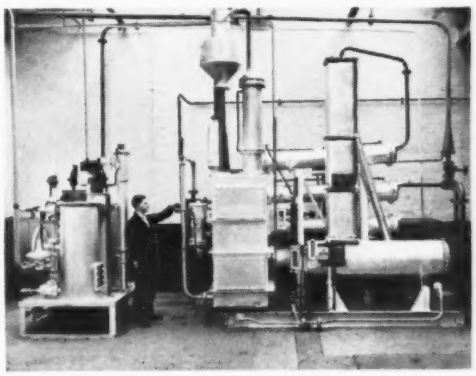
Solution

Nitrogen is clearly the most suitable atmosphere for this operation. For the batch process, gas of the required purity is derived from cracked and burned ammonia, which contains no carbon. Metalectric Furnaces Ltd., Smethwick, have recently given careful thought to reducing the cost of the process; and savings have now been achieved in two ways. A continuous process has been developed using a continuous mesh belt furnace to stress-relieve small packs of laminations. This method reduces the heat treatment cycle to one hour compared with the 40 or more hours of the batch process. Since the time at high temperature has been greatly reduced, there is a corresponding reduction in the risk of carbon pick-up. This in turn has meant that the nitrogen atmosphere derived from the combustion of a fuel gas can be used for the process: and this atmosphere is only one-fifth the cost of nitrogen derived from cracked and burned ammonia.

Results

The overall cost of stress-relieving in lift-off furnaces varies between £8 and £10 per ton; by the continuous method, using a cheaper atmosphere, costs are between £5 10s. 0d. and £7 10s. 0d. per ton—a very appreciable saving.

The nitrogen plant shown produces 1,000 cubic feet of nitrogen per hour with a dewpoint of minus 30°F. The continuous furnace served by this generator stress-relieves 450 to 500 pounds of laminations per hour.



Photograph by courtesy of The Incandescent Heat Co. Ltd.

"ATTACOTE"

A new anti-caking agent for Hygroscopic Chemicals

DETAILS have recently been announced of a new anti-caking agent, ATTACOTE, developed by the Minerals and Chemicals Corporation of America. Field tests in the form of commercial applications have been carried out during the past year and indicate that the new material is superior to many agents currently used for coating prilled, granular and explosives grade ammonium nitrate, ammonium sulphate, urea, high analysis granular fertilizers and certain resins including urea-formaldehyde.

A magnesium aluminium silicate, Attacote is stated to have the following properties and chemical analysis.

Average Particle Size (Microns)	8
Ultimate Particle Shape	Needle-like
Oil Absorption (ASTM D281-31)	79.8
Free Moisture, 220° F. (as produced) wt. % ...	2.0
Ignition Loss, 1,800° F. (as produced) wt. % ...	7.0
pH	8.5
Colour	Cream
Specific Gravity	2.47
Residue 325 mesh (wet) wt. %	2.0
Bulk Density (packaged condition) lb./cu. ft. ...	16
Surface Area, sq. metres/gm.	125

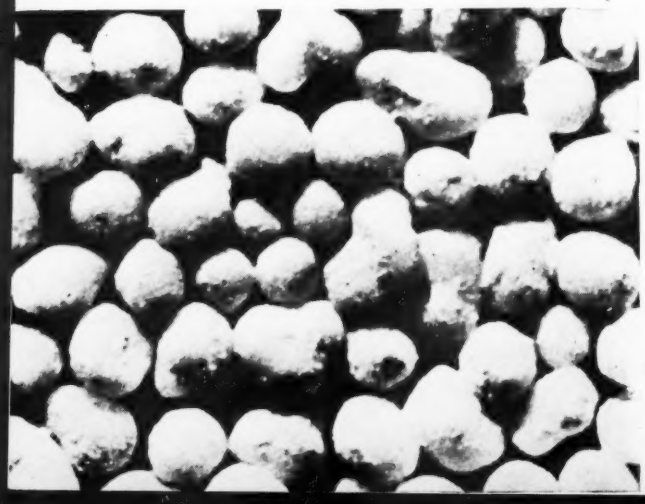
Typical Chemical Analysis of ATTACOTE

(Volatile—Free Basis)

Silicon (SiO_2)	67.0%
Aluminium (Al_2O_3)	12.5%
Iron (Fe_2O_3)	4.0%
Magnesium (MgO)	11.0%
Calcium (CaO)	2.5%
Other	3.0%
	100.0%

ATTACOTE 'C,' a modified grade, claims an ammonia release specification of 0.025 gm.NH_3 per 25 gm. and in addition to good adherence qualities, Attacote is said to be inert and non-toxic with a low bulk density giving a high covering power. Its excellent dessicant properties, which stem from its needle-like particle structure and resulting large surface area, contribute to its outstanding qualities as a coating agent.

Ammonium nitrate prills coated evenly with "Attacote"



"JETLOADER"

Development in Ammonium Nitrate Blasting Technique

A NEW SYSTEM for loading blast holes with fertilizer-grade ammonium nitrate has been developed by the Atlas Powder Company of Wilmington, Delaware, one of the leading manufacturers of explosives in the United States. A "jetloader" is used to blow the blasting agent and sand stemming into blast holes. Tests have shown that a mixture of fertilizer-grade ammonium nitrate and diesel oil can be blown into a 50 to 60 foot horizontal blast hole at a rate of 2½ pounds per second.

The only basic equipment required for use with the "jetloader" includes a compressor to provide air at 45 pounds per square inch, a lorry to move the compressor and the "jetloader" itself and enough 1½ inch plastic pipe to reach from the machine to the bottom of the blast holes. The only moving parts on the "jetloader" are the closing device and an air valve.

In one recent test, a crew of three men primed, loaded and stemmed five holes, varying in depth from 75 feet to 90 feet, in 90 minutes. Each hole was primed with 80 pounds of explosive in 2-inch diameter cartridges screwed together to form a continuous primer 40 feet long. Detonating fuse was connected to the outer end of the primer and the primer column was inserted to the back of the hole. The plastic pipe was placed in turn in each hole and a total of 2,320 pounds of ammonium nitrate was mixed with diesel oil and blown into the holes. The bags of ammonium nitrate were emptied directly into the machine, diesel oil being poured in simultaneously at a rate of one gallon to every 80 pounds of ammonium nitrate. The mixing occurs in the chamber from which it is blown under pressure. Each hole is tamped by blowing in 10 to 15 feet of sand. On detonation, excellent fragmentation resulted.

Saving time and manpower, the "jet-loader" greatly facilitates loading fertilizer grade ammonium nitrate into horizontal blast holes and improves its detonating effect. In wet holes it has made possible the use of ammonium nitrate with a high explosive core and it also holds possibilities for efficient loading of vertical holes.

Ammonium nitrate is the principal end-product of the Atlas Powder Company's plant at Reynolds near Tamaqua, Pa., where nitric acid is manufactured in a du Pont type high pressure unit with a daily production capacity of 65-70 tons (100% HNO_3) in the form of 58-60% acid. At the end of 1958 the Atlas Powder Co. closed its nitroglycerine plant at White Haven, Pa., and has now concentrated all its explosives production at the Reynolds plant. This step was taken as a result of the fall in demand for nitroglycerine in the United States, particularly noticeable in the anthracite mining areas. At the same time the demand for ammonium nitrate for use as an explosive is growing.

Loading ammonium nitrate and diesel oil into the "Jetloader," operating on compressed air at 40 p.s.i.

current events

ARGENTINA

Expansion Projects

Nitrogen production in Argentina is confined to a modest output of by-product ammonium sulphate, some 2,000 tons N a year, but immediate expansion plans will raise this to an annual level of 10,000 tons N within the next five or six years. The establishment of a nitrogen fertilizer industry on the basis of ammonia synthesis may only materialise if plans of Carbometal, a consortium of Argentinian and German interests, are fulfilled; these provide for the erection of a plant in the province of Mendoza to produce urea and calcium cyanamide.

The bulk of the planned additional production will come from the San Nicholas steel works and a plant under construction for Fabriciones Militaires at Rio Tercero near Cordoba. It is intended that some 20,000 tons of ammonium sulphate a year will be recovered as a by-product at the San Nicholas works, while the Rio Tercero plant will have a planned annual capacity of 15,000-20,000 tons of ammonium sulphate. Completion of the latter plant, originally intended for 1958, has been delayed and as yet production of ammonium sulphate on a commercial scale has not started. A third source of supply will be the three blast furnaces to be built for Sociedad Mixta Siderurgica Argentina (SOMISA) each with a capacity of 7,900 tons of ammonium sulphate. The first of these is due to come into operation by the end of this year, the second in 1962 and the third in 1969.

Consumption of nitrogenous fertilizers in Argentina does not at present exceed 10,000 tons N a year. Chilean nitrate and ammonium sulphate, the latter imported from Austria, Belgium, France and the Netherlands, each account for one-third of the total. The balance, most of which is imported from the United States, is made up of ammonium phosphates and mixtures, and recently, small quantities of urea. There have been no direct imports of fertilizer-grade urea, but an estimated 1,500 tons imported for the plastics industry and in excess of requirements was sold as fertilizer in 1958.

As the consumption of nitrogen fertilizer in relation to the area of cultivated land in Argentina is among the lowest in the world, it is expected that the availability of domestic supplies will act as the stimulus for a substantial rise in demand. Consequently, the volume of imports should be at least maintained for the next five years.

BRAZIL

Expanding Nitrogen Industry

When the third of three new plants is brought into operation Brazil will be capable of meeting over 75% of her nitrogen fertilizer requirements. Consumption is now at a level of 33,000 tons N, having risen by 73% since 1951, and whereas then Chilean sodium nitrate accounted for the bulk of supply, ammonium sulphate is now used in greater quantities than any other material.

Until 1958, when the first synthetic ammonia plant was commissioned, virtually all Brazil's nitrogen requirements were met by imports and even to-day they still account for two-thirds of the total consumption.

Imports (000 tons N)

	1953/54	*1957/58*
Ammonium sulphate ...	4.5	11.5
Ammonium nitrate	.9	4.0*
Sodium nitrate	12.6	8.1
Urea	2.0	2.0
Others	.5	2.7
	20.5	**28.3**

* Including lime ammonium nitrate.

Domestic production of nitrogen in Brazil was, prior to 1958, solely in the form of ammonium sulphate obtained as a by-product of the steel mills operated by Cia. Siderurgica Nacional at Volta Redonda. Production is now at an annual level of 2,000 tons N, somewhat higher than in recent years as a result of extensions carried out at the works in 1958.

The first synthetic nitrogen plant in Brazil was commissioned in February 1958 by the state-owned oil company, Petroleo Brasilero S.A. (Petrobras). Built by Foster Wheeler Corp. at Cubatao near Santos in the province of Sao Paulo, the new plant employs the Casale process and has an annual capacity of 33,000 tons of ammonia based on the use of waste gas from the adjacent oil refinery. Ammonia and nitric acid produced at Cubatao are used in the manufacture of 100,000 tons of calcium nitrate and 10,500 tons of ammonium nitrate a year. It is reported that the ammonium nitrate is being further processed to lime ammonium nitrate and that the installation of a urea plant is under consideration.

Brazil's second synthetic nitrogen plant was commissioned this summer by Nitrogenio S.A. at Aratu in Bahia State. Built by The Japan Plant Association, the new works has an annual capacity of 30,000 tons of ammonia based on the use of waste gases from the Mataripe oil refinery. Nitric acid, calcium nitrate and lime ammonium nitrate are the principal end products to which eventually urea may be added.

The third new nitrogen plant in Brazil is being built for Fertilizantes Minas Gerais (Fertisa) at Vespasiano, but technical difficulties have temporarily slowed up construction. This plant, like that operated by Petrobras, will use waste gases from the Cubatao oil refinery to produce 25,000 tons of calcium nitrate a year.

The new Brazilian nitrogen industry is finding some difficulty in competing with imported material because of high production costs. The Government has, however, been trying to assist domestic producers by allowing exemption from consumption taxes, permitting duty-free imports of processing machinery, reducing freight rates on the state-owned railways, establishing higher tariffs on fertilizer imports and by granting direct subsidies.

Although domestic producers can in future be expected to attain a higher standard of operational efficiency with a resultant reduction in prices, they are unlikely to capture the

entire market. The availability of increased supplies is in itself acting as a stimulus to consumption and it is reasonable to assume that a substantial but declining proportion of Brazil's nitrogen requirements will be met by imports for several years to come.

CANADA

Nitrogen Project at Maitland, Ont.

Sogemines Ltd., an affiliate of the Soc. Générale de Belgique will produce anhydrous ammonia, ammonium nitrate and nitrogen solutions in a plant to be built at Maitland, Ontario. Hydrogen will be obtained from Alberta natural gas supplied by Trans Canada Pipelines Ltd. The new plant will have an annual capacity of 66,000 tons of anhydrous ammonia, 42,000 tons of prilled ammonium nitrate and 42,000 tons of nitrogen solutions and, under a long term contract, will supply the neighbouring works of du Pont of Canada with quantities of hydrogen and anhydrous ammonia.

The contract for design and construction of the new plant will be awarded by November and it is hoped to start production in 1961. The Maitland plant, together with that under construction for the Consolidated Mining and Smelting Co. at Turner Side, Alberta, and extensions to Sherritt Gordon Mines Works at Fort Saskatchewan will raise Canada's nitrogen capacity to 451,000 tons N, the ninth largest in the world.

COLOMBIA

Delayed Completion of Barrancabermeja Works

Work on the erection of Colombia's first nitrogen fertilizer works, begun three years ago at Barrancabermeja, has been held up by lack of funds. It is planned to use natural gas from the Shell Company's oil fields at Casabe to obtain hydrogen for ammonia synthesis by the Fauser-Montecatini process, and the plant will have a capacity of 17,000 tons of anhydrous ammonia a year. Ammonia will be used in the manufacture of up to 10,500 tons of urea and 32,000 tons of ammonium nitrate a year. The project is being handled by the Instituto de Fomento Industrial and when completed the plant will be operated by Industria Colombiana de Fertilizantes, S.A.

The capital cost of the Barrancabermeja project has been estimated at U.S. $8 million and it is hoped that much of this will be provided by a United States Export-Import Bank loan which has not, as yet, been obtained. It is, however, hoped to complete the plant during 1960. Although consumption of fertilizer nitrogen in Colombia has doubled within the last five years it does not at present exceed 7,000 tons N a year; supplies in 1958 being obtained from Belgium, West Germany, the Netherlands, the United States and Chile. The production capacity of the new plant is double the present level of consumption, but this is expected to expand sufficiently to absorb the new output without reducing the present level of imports on which only the availability of foreign exchange is likely to impose a limit.

CUBA

The Matanzas Project

The first synthetic nitrogen plant in Cuba is now under construction for the Cuban Nitrogen Company and is expected to come into operation in 1961 with an annual capacity of over 110,000 tons N. The new plant will be located in the industrial city of Matanzas near the rayon plant operated by Industrias Consolidadas de Matanzas S A.

Ammonia synthesis will be based on the use of residual fuel oil from local refinery operations and possibly on imported fuel oil. It is reported that the capacity of the various units in the Matanzas plant will be as follows :

	short tons per year
Ammonium nitrate	60,000
Ammonium sulphate	58,000
Captive anhydrous ammonia ...	42,000
Nitric acid	59,000
Nitrogen solutions	50,000
Urea	17,000

While the bulk of the production will be sold for fertilizer application, some of the ammonium nitrate will be used for explosives and a portion of the urea output will be used in the manufacture of plastics.

The ammonia synthesis, urea and ammonium sulphate units at Matanzas are to be built by the Italian firm of Oronzio de Nora, the nitric acid and ammonium nitrate installations being supplied by the Chemical and Industrial Corporation of Cincinatti, Ohio.

Cuba is at present dependent on imports for her supplies of fertilizer nitrogen, amounting to some 21,000 tons N a year. The new indigenous supply will undoubtedly raise the level of consumption but it is unlikely that this expansion will be great enough to provide a market for imports at their present level. The wide range of products of the new plant should put it in a strong position to meet the diverse domestic demands and if necessary to compete in nearby export markets.

FINLAND

Oulu Plant to be extended

Production at the nitrogen fertilizer works operated by Typpi Oy at Oulu, 140 miles from the Arctic Circle, exceeded the nominal plant capacity of 32,000 tonnes N a year in 1958, when total production of the plant amounted to 34,649 tonnes of nitrogen—some 5,000 tonnes more than the output for 1957. The compound fertilizer plant, commissioned in July 1957, was not in operation for part of the year, but during this period production of lime ammonium nitrate was increased. Typpi Oy are licensed to use the Carbo-nitric process developed by Potasse et Engrais Chimiques for the manufacture of not more than 200 tonnes of compound fertilizers daily. It has recently been announced that the capacity of the Oulu works is to be raised by 30% to 48,000 tonnes N a year.

Ammonia production at Oulu started in 1952 and is based on the gasification of pulverized coal or the use of heavy fuel oil. Upper Silesian gas coal was used at first employing the Koppers Totzek gasification process, but Bunker C oil is the raw material used at present, 42,764 tonnes having been consumed in 1958. Production and sales in 1958 were as follows :—

	Production	*Sales*
	(in tonnes)	
Lime ammonium nitrate (25% N) ...	109,824	92,219
Compound fertilizers (12:9:17 and 14:11:12)	20,675	18,769
Nitrogen solutions (40% N)	6,229	5,815
Liquid ammonia—technical grade ...	1,820	1,820
Liquid ammonia—refrigerating grade	100	98
Aqua ammonia (25% NH_3)	1,162	1,161
Nitric Acid (50% b.w.)	446	446

The Oulu plant now supplies about 80% of Finland's requirement of fertilizer nitrogen which has risen by 62% since 1952. The balance is imported, mainly from Norway.

	Production of Typpi Oy	Consumption of Fertilizer Nitrogen
	(tons of nitrogen)	
1952 ...	1,009	27,978
1953 ...	13,071	30,762
1954 ...	17,265	33,163
1955 ...	16,637	33,192
1956 ...	16,669	41,484
1957 ...	29,807	43,616
1958 ...	34,649	45,200

The projected increase in capacity will enable Typpi Oy to retain its share of the domestic market for the next five or six years if, as is expected, the present steady rise in consumption is maintained.

IRAN

The Shiraz Project

Work has started on the pipeline to supply Iran's first nitrogen fertilizer plant, which will be built at Shiraz. The Minister of Industry and Mining recently signed a contract with the Anglo-French consortium ENSA in which Cie. Schneider, Ste. Entrepose and Constructors John Brown Ltd. are represented—for the construction of the pipeline and nitrogen fertilizer works. Societá Montecatini have been appointed Consultants for the entire project, estimated to involve an outlay of $30 million.

A 10" diameter pipeline will bring natural gas 140 miles from the Gach Saran field to Shiraz where, in addition to supplying the nitrogen works, it will be distributed for town services and will be used in local industries. Fauser-Montecatini processes will be employed in the nitrogen works which will have a capacity of 100 metric tons of anhydrous ammonia per day. End-products will be either ammonium nitrate or lime ammonium nitrate; a proposal has been submitted to the Iranian Government that fertilizer manufacture should include urea but no final decision has been reached.

Consumption of fertilizer nitrogen in Iran is at present less than 2,000 tons N a year and although supplies from the Shiraz plant will themselves stimulate demand there is unlikely to be any appreciable rise in the level of imports, unless it is financed by a foreign loan.

TURKEY

Nitrogen Project at Kutahya

Good progress is reported from Kütahya, where the first major nitrogen fertilizer works in Turkey is being built. The new plant, due to come into operation in the summer of 1960,

will have, on a basis of 300 working days a year, an annual capacity of 60,000 tons of ammonium sulphate and 50,000 tons of lime ammonium nitrate. Production will also include 5,000 tons of concentrated nitric acid, 1,000 tons of liquid ammonia and 1,000 tons of technical grade ammonium nitrate. The Kütahya project is being financed by the West German firm of Badische Anilin und Soda Fabrik A.G., who are also providing the installations and equipment. Another West German firm, Friedrich Uhde G.m.b.H. has been charged with technical consultancy and supervision of the construction work.

The principal raw material to be employed at Kütahya is lignite supplied from the Seyitömer mines, some 15 miles from the works, and consumption, for gasification and steam raising is expected to amount to 300,000 tons a year. Gasification will be effected in two Winkler generators, and in the desulphurization of synthesis gas indigenous limonite will be used at a rate of 4,000 tons a year. Two ammonia synthesis reactors will be used, each with a working pressure of 3,250lb. per square inch and a daily capacity of 60 tons.

Part of the ammonia output is to be used in the manufacture of weak nitric acid, pre-oxidation being effected in two ammonia combustion furnaces. Following oxidation, a weak nitric acid will be obtained by absorption of HNO_3 in water. Concentrated nitric acid will be produced from reactors operating with oxygen at a pressure of about 700lb. per square inch. Weak nitric acid will be neutralised with ammonia to produce ammonium nitrate which is to be processed to lime ammonium nitrate, the lime being a by-product from the manufacture of ammonium sulphate.

Ammonium sulphate production is being based on the use of gypsum, of which 96,000 tons a year will be required. It is estimated that the gypsum deposits supplying the Kütahya works contain about 100 million tons of high grade material. Power requirements at the new works will amount to 130 million KWH annually and are to be supplied by a nearby power station.

Producing some 25,000 tons of nitrogen a year, the Kütahya works will be in a position to meet Turkey's requirements of nitrogen fertilizers until 1965 unless the growth of demand is appreciably accelerated. Consumption has risen by 63% since 1953/54 and is now at an annual level of 14,000 tons N, virtually all of which is imported from Western Europe and is for the most part in the form of ammonium sulphate. Western Germany was an important supplier in 1958, shipping some 21,000 tons of ammonium sulphate.

It has recently been reported that Turkish interests are considering enlisting foreign capital to establish the manufacture of urea, originally to have been produced at Kütahya, calcium carbide, acetylene and calcium cyanamide. The output of such a plant would, with supplies from Kütahya, be expected to stimulate nitrogen consumption in Turkey but its effect on the volume of imports would be adverse.

Statistical Appendix

W. Germany

EXPORTS 1958

Metric Tons N

Lime Ammonium Nitrate and Ammonium Sulphate Nitrate	
Denmark	1,981
Finland	9,598
Greece	3,598
Jugoslavia	2,740
Netherlands	6,556
Portugal	6,646
Spain	18,359
Egypt	25,341
Rhodesia and Nyasaland	2,729
South Africa	1,817
Costa Rica	407
Cuba	182
Mexico	6,629
Salvador	1,318
Brazil	4,263
Colombia	159
China	20,991
India	3,777
Israel	1,200
Korea	14,085
Libya	735
Syria	1,294
Australia	571
New Zealand	200
Others	2,721
Total	**137,897**

Ammonium Sulphate	
Belgium	3,800
Denmark	2,007
Greece	3,760
Eire	3,250
Portugal	6,638
Sweden	1,49[illegible]
Spain	31,80[illegible]
Turkey	4,195
Rhodesia and Nyasaland	4,072
South Africa	3,177
Salvador	3,93[illegible]
Brazil	10,47[illegible]
China	64,962
Indonesia	3,544
Korea	24,520
Pakistan	1,93[illegible]
Philippines	1,60[illegible]
Vietnam	1,299
Others	14,322
Total	**188,825**

Japan

EXPORTS 1958

Metric Tons N

Ammonium Sulphate	
Okinawa	3,066
Korea	1,792
Taiwan	87,151
China	40,900
Philippines	1,060
South Vietnam	3,903
Siam	1,560
Indonesia	5,304
India	10,129
Pakistan	4,376
Others	3,223
Total	**162,464**

Urea	
Okinawa	45
Korea	16,130
Taiwan	2,920
China	20,000
Philippines	4,500
South Vietnam	1,000
Siam	100
India	6,450
Pakistan	2,510
United States	240
Mexico	1,82[illegible]
Brazil	4,33[illegible]
Australia	1,580
Iran	450
Others	329
Total	**62,304**

Netherlands

EXPORTS 1958

Metric Tons N

Ammonium Sulphate	
Eire	4,597
Sweden	705
Portugal	355
Spain	18,393
Greece	2,924
Sudan	497
Canary Islands	990
South Africa	1,779
Rhodesia	792
Salvador	900
Jamaica	946
Colombia	139
Surinam	116
Brazil	2,088
Argentina	1,171
Indonesia	4,412
Ceylon	1,447
Burma	594
Siam	2,020
South Vietnam	393
China	9,422
South Korea	10,350
New Zealand	159
Uruguay	376
Others	702
Total	**66,203**

Urea	
Belgium	445
Great Britain	20
France	133
Eire	20
Sweden	500
Denmark	24
Portugal	179
Spain	375
Greece	34
Poland	70
Sudan	4,063
Belgian Congo	32
Kenya	72
Tanganyika	61
Portuguese East Africa	10
Rhodesia	262
South Africa	1,35[illegible]
United States	1,33[illegible]
Guatemala	116
Central America	343
Colombia	358
British Guiana	59[illegible]
Ecuador	8[illegible]
Brazil	1,305
Argentina	551
India	4,064
Ceylon	7[illegible]
Malaya	1[illegible]
Philippines	320
China	9,000
Australia	38[illegible]
Total	**25,842**

Belgium

PRODUCTION

Metric Tons

		Synthetic Ammonia		By-product Ammonium Sulphate	Fixed Nitrogen for technical use	Compound Fertilizers	
		Total N content	Fertilizer N content	N content	tons product	tons product	N content
1957	1st quarter	52,112	42,797	4,368	2,612	52,089	4,064
	2nd quarter	59,877	43,445	4,067	1,998	31,282	2,873
	3rd quarter	58,429	52,404	4,431	1,892	35,491	2,504
	4th quarter	63,279	57,930	4,136	1,533	38,125	1,775
1957	**TOTAL**	**233,697**	**196,576**	**17,002**	**8,035**	**156,987**	**11,216**
1958	1st quarter	64,691	58,723	4,255	1,401	66,461	6,768
	2nd quarter	68,079	63,747	4,871	1,734	56,199	6,236
	3rd quarter	69,684	50,465	4,572	1,545	46,726	4,171
	4th quarter	72,469	66,189	4,543	1,764	72,292	5,521
1958	**TOTAL**	**274,923**	**239,124**	**18,241**	**6,444**	**241,678**	**22,696**

EXPORTS 1958

Ammonium Nitrate		Ammonium Sulphate *			
Portugal	4,725	Spain	17,877	S. Korea	23,193
China	33,347	Greece	3,005	Ceylon	4,837
Egypt	36,166	Eire	2,949	Malaya	7,565
Yugoslavia	15,051	Portugal	3,166	Peurto Rico	2,821
Total	**89,289**	China	62,636	**Total**	**128,050**

* Includes Lime Ammonium Nitrate

United Kingdom

EXPORTS OF SULPHATE OF AMMONIA

Fertilizer Years Ended 30th June
Long Tons

	Actual Shipments						
Destination	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58
Scandinavia	357	366	152	367	216	267	282
Holland and Belgium	19	7	14	3	14	12	4
Portugal	10,330	19,970	9,999	10,669	—	—	5,820
Spain	9,523	10,023	—	9,639	—	—	29,528
Other Europe	560	4,470	700	499	451	700	700
Palestine/Israel	2,106	4,496	5,435	4,507	97	—	—
Other Levant	11,680	14,225	7,153	9,228	—	—	8,304
India, Pakistan and Burma	35,904	35,230	22,809	21,058	30,442	423	10
Ceylon	33,999	59,948	60,604	53,260	11,321	10,454	90,686
Malaya and British Borneo	27,463	18,498	19,990	24,074	14,680	7,653	53,411
Indonesia	4	8	—	488	1,201	—	—
China and Hong Kong	34,934	109,942	4,146	4,370	699	—	2,855
Other Asia	1,605	28,056	1,897	1,062	24	50	3,755
Madeira	—	487	—	—	—	—	—
Canary Islands	8,928	541	886	3,965	—	—	9,746
Egypt	15	15	68	80	76	3	—
Sudan	500	8,929	11,197	9,999	—	487	2,191
West Africa	9,189	6,719	4,119	3,068	2,030	183	948
East Africa	4,995	3,542	4,458	6,840	1,990	2,491	5,449
South and Central Africa	18,739	19,288	13,752	22,387	2,226	2,803	2,552
Mauritius	21,868	14,388	25,158	21,445	14,479	5,698	21,548
Other Africa	215	—	6	1	10	5	10
Australia	24,000	—	18,369	21,604	9,700	—	20,848
New Zealand	2,395	1,458	3,500	3,237	1,034	548	1,864
Fiji Isles	3,254	4,075	4,135	4,905	2,446	4,625	6,830
Canada and Newfoundland	126	246	471	462	436	309	266
U.S.A.	60	12,858	—	—	—	—	—
Central America	515	3,016	329	239	210	107	—
British West Indies	41,988	39,021	40,613	37,645	17,457	9,906	19,875
British Guiana	14,208	9,005	9,121	12,730	6,039	3,904	15,636
Other South America	44	106	196	217	43	4	59
Total	319,523	428,933	269,277	288,048	117,321	50,632	303,177
Channel Islands	539	2,001	1,164	1,635	1,670	1,127	1,033
Eire	28,057	24,643	28,575	18,995	6,223	76	1,718
Total Exported	348,119	455,577	299,016	308,678	125,224	51,835	305,928

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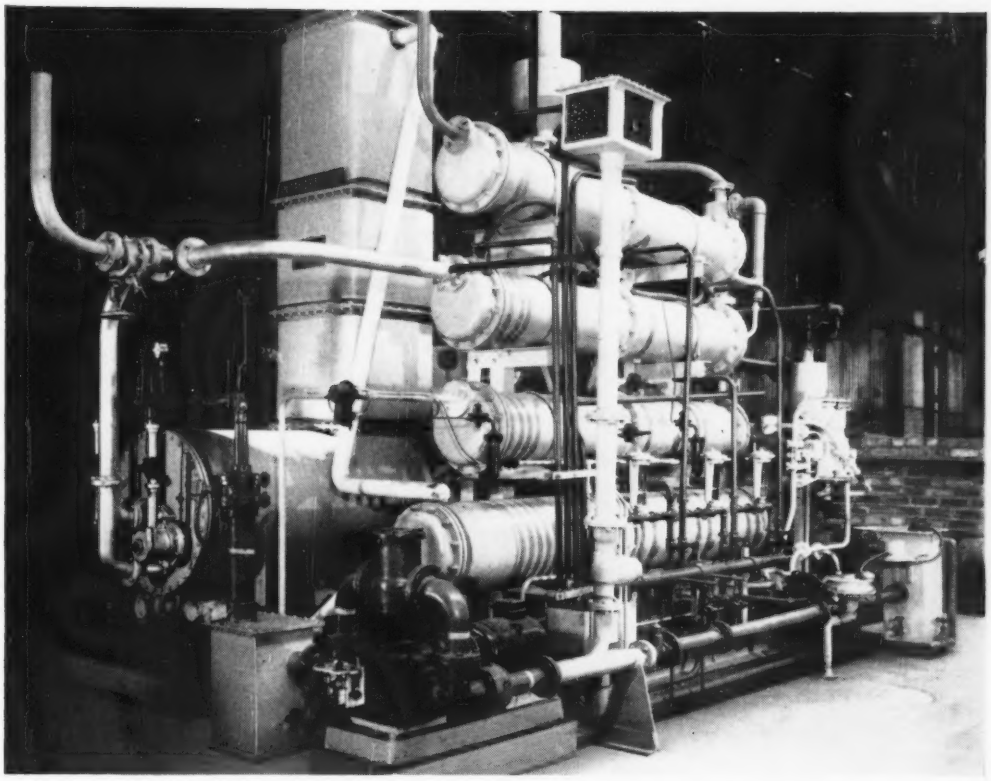

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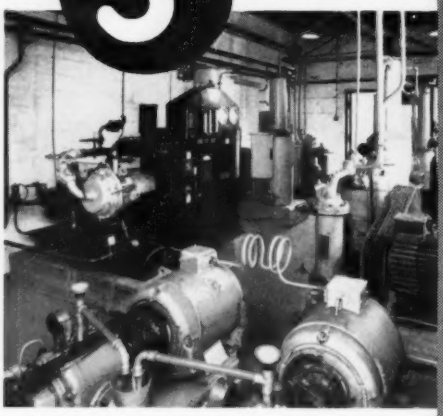

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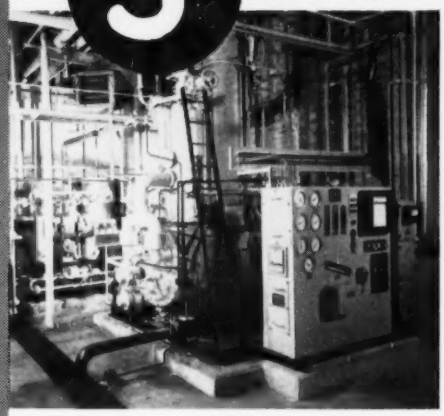

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